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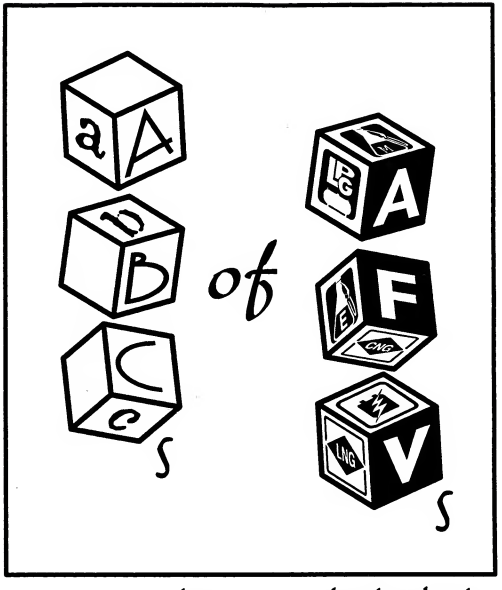


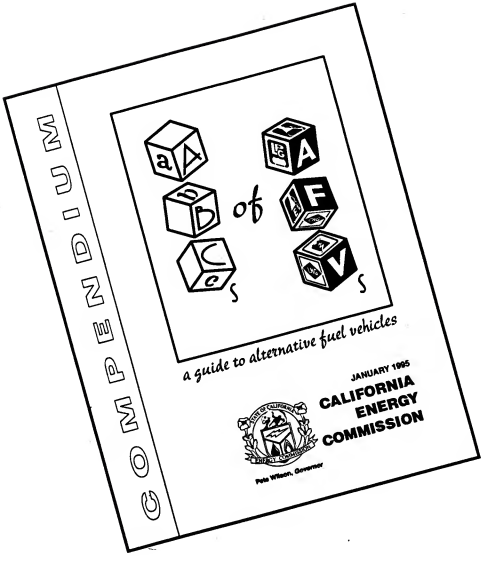
a guide to alternative fuel vehicles

JANUARY 1995

CALIFORNIA ENERGY COMMISSION

Pete Wilson, *Governor*

P180-95-001



CALIFORNIA ENERGY COMMISSION

Bob Aldrich, *Principal Author*
Claudia Chandler, *Assistant Director*
MEDIA & PUBLIC COMMUNICATIONS OFFICE

B. B. Blevins, *Executive Director*
EXECUTIVE OFFICE

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for the
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ANY CORRECTIONS OR ADDITIONS
TO THE VARIOUS CONTACTS LISTS ARE APPRECIATED.
THE LISTS WILL EVENTUALLY BE PUT ON THE INTERNET
AT THE CALIFORNIA ENERGY COMMISSION'S WORLD WIDE WEB
AND GOPHER SITES.

SEND UPDATED INFORMATION TO:
bobo@sno.com or call 916-654-4993.

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Introduction

The California Alternative Fuel Vehicle Partnership is a coalition of private companies; automobile makers; fuel providers; and federal, state and local government agencies that have banded together to support the introduction and commercialization of clean, alternative fuels and vehicles that use those fuels. The partnership is a means by which to share information with fleets and fleet managers who are required by law (or who desire) to purchase alternative fuel vehicles before the end of the decade. It is also a channel to inform and educate the general public and California drivers about the various clean, alternative fuels that are available today and in the future. The founding sponsors include:

California Energy Commission *(partnership chair)*
California Department of Transportation
California Department of General Services, Office of Fleet Administration
California Electric Transportation Coalition
California Natural Gas Vehicle Coalition
Regional Clean Air Coalitions
Sacramento Metropolitan Air Quality Management District
South Coast Air Quality Management District
U.S. Department of Energy
U.S. General Services Administration

This report was prepared by thestaff of the **California Energy Commission** with input from various sponsoring members. The Commission is the state's primary energy policy and planning agency and has been involved in the testing and demonstrating of alternative transportation fuels since 1978. As part of the state's energy policy, the Commission supports the use of clean, alternative fuels to reduce our state's dependence on petroleum and to improve air quality.

The Energy Commission has been involved in all areas of transportation fuel research, development, demonstration and commercialization. It has worked with automobile and heavy-duty vehicle and engine manufacturers to advance the state-of-the-art of alternative fuel technology. By doing so, California continues its international leadership in alternative energy and helps create economic advantages for our state.

Acknowledgements

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Chapter 1

An Overview of Alternative Fuel Vehicles

What Are Alternative Fuel Vehicles?

Alternative Fuel Vehicles (AFVs) are vehicles that run on fuels other than petroleum products. They have been with us in one form or another for more than one-hundred years. Only recently, however, have they become more commonplace.

According to the definition in federal law, alternative fuels include:

- Alcohol fuels such as methanol (methyl alcohol), denatured ethanol (ethyl alcohol) and other alcohols, in pure form (called "neat" alcohols) or in mixtures of 85 percent by volume (and mixed with up to 15 percent unleaded regular gasoline – M85 and E85) or more
- Compressed natural gas (CNG)
- Electricity
- Hydrogen
- Liquefied natural gas (LNG)
- Liquefied petroleum gas (LPG)
- Coal-derived liquid fuels
- Fuels other than alcohols derived from biological materials: like soy bean, rapeseed or other vegetable oil-based fuels

These fuels are described more completely in the chapters that follow.

Vehicles using these fuels can be either original equipment manufactured (OEM) vehicles made by auto companies, retrofits or conversions.

Before the introduction of gasoline as a motor fuel in the late 1800s, vehicles were often powered by what are now considered alternative fuels. For example, illuminating or coal gas (a form of methane or natural gas) was used in early prototype internal combustion vehicles in the 1860s. Electricity, stored in lead acid batteries, was a popular energy source for vehicles from as early as 1830s to 1920s. In the 1880s, Henry Ford built one of his first automobiles and fueled it on ethanol, which was often called "farm alcohol" because it was made from corn. His early Model Ts were designed with an adjustable carburetor to allow them to run on alcohol fuel. Liquefied petroleum gas (commonly called propane) has been used as a transportation fuel for more than 60 years.

In those early years of the horseless carriage, naturally formed gasoline was expensive and often sold by the pint in pharmacies; it was also used as a cleaning solvent. New petroleum refining technologies (thermal cracking and eventually catalytic cracking), however, produced gasoline inexpensively; and gasoline, because of its high energy content, became the fuel of choice for internal combustion engines.

Now many of these "alternatives" to gasoline are returning to the transportation fuel market, driven by state and federal government mandates for cleaner alternatives to gasoline and diesel. Alternative fuels are needed for two main reasons: energy security and air quality.

Why AFVs Are Important

California's transportation system is vital to the state's economy, but our gasoline- and diesel-fueled cars, buses and trucks are also our greatest source of air pollution. As oil prices have dropped throughout the world, as the number of registered vehicles has increased and because we often live farther away from our work, Californians are driving more today than we did just five years ago. As a consequence, California's cities and countrysidare frequently blanketed by smog.

To attack California's air quality problem, the Governor, the Legislature, the California Energy Commission, the Air Resources Board and other California public agencies assumed a national leadership role and committed to fuel diversity with cleaner, alternative fuels and a market for the vehicles that use those fuels.

Working with automakers, fuel producers and utility companies, air quality districts, and the private and public sector, California is making progress toward achieving a truly diverse transportation landscape –

California Vehicle Statistics					
	1989	*1990*	*1991*	*1992*	*1993*
Total Registered Vehicles	22,367,821	22,678,552	22,957,474	22,793,908	22,982,288
Vehicle Miles of Travel (in millions of miles)	134,371	139,209	139,680	141,686	142,343
Taxable Gasoline Sales (millions of gallons, excluding aviation fuel)	13,206	13,377	13,160	13,064	13,202

one that will provide the consumer competitive choices in transportation technology, fuels and fueling options, while meeting California's increasingly stringent clean air goals.

These choices will include not only reformulated gasoline and clean diesel to fuel our transportation but also electric, ethanol, methanol, natural gas and propane-powered vehicles, each operating in their optimal capacities for fuel efficiency and lowered emissions.

The use of alternative fuels for transportation can have a tremendously positive impact on California's economy. Using alternative fuels can help stop the outflow of jobs and dollars caused by buying oil produced outside of our state.

California produces only 45 percent of the oil it consumes. About 51 percent comes from Alaskan oil fields; the remaining four percent comes from foreign sources (mostly Indonesia). This will change as California's and Alaska's oil production decreases. The Energy Commission's *1993 Fuels Report* estimates that Alaska's oil production will decline six percent between 1992 and the year 2000. Production from 2000 to 2015 will decline more sharply, 15 percent per year. California's production is also expected to shrink. Foreign sources of crude oil will be relied upon more heavily in the future unless alternatives are found to replace this loss of domestically-produced fuel.

Alternative Fuels Are Cleaner

Alternative fuels are inherently cleaner than gasoline because they are chemically less complex than gasoline, and when oxidized or burned, they burn "cleaner" with fewer emissions.

Consider the following chemical equations for various fuels:

Ethanol – CH_3CH_2OH

Methanol – CH_3OH

Natural Gas (Methane) – CH_4

Propane – C_3H_8

Gasoline's Octane Molecule – C_8H_{18}
(one of the many component molecules found in gasoline)

It can be seen just on this very simple level that these molecules are less complex. The longer and the more chemically complex a molecule is, the less likely it is to be completely burned. This incomplete combustion of the molecule in an internal combustion engine releases carbon monoxide, nitrogen oxide and other molecules in the emissions. Alternative fuels,

because of the simplier chemical make up, release fewer emissions from incomplete combustion. The fact that alternatives are cleaner can be proven by the actual use of the fuel in a motor vehicle and running emissions testing.

Electric vehicles, which have no internal combustion engine, offer an even better alternative because they do not burn a fuel. Their only sources of "pollution" are the power plants that create the electricity, which can also be regulated more closely for their sources of pollution.

Emission Characteristics of Alternative Fuels

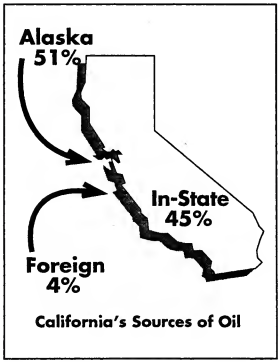
From 1992 to 1994, one of the most comprehensive side-by-side studies of alternative fuels was conducted by Battelle Memorial Institute on vehicles in Southern California. The CleanFleet Project, or the South Coast Alternative Fuels Demonstration Project, tested six fuels in 111 Federal Express delivery vans, which drove more than three million miles during the two-year study. The study used Chevrolet, Dodge and Ford vans that were similar in characteristics and in usage.

Preliminary emission results from the study (final technical results will be released in July 1995) indicate that all five of the fuels: compressed natural gas, electricity, methanol, propane and reformulated (Phase 2) gasoline bested regular gasoline in nearly all emissions. (Ethanol was not used in this test because of its limited availability in California.) Vans fueled with regular unleaded gasoline were used as a control group by which the other fuels were compared.

The alternative fuels had less emissions than regular gasoline and were better than reformulated gasoline. Use of compressed natural gas showed carbon monoxide (CO) levels of 65 to 76 percent less than regular gasoline. Ozone reactivity for CNG was 89 to 96 percent cleaner than gasoline. Methanol vehicles had 37 percent less CO emissions than gasoline and up to 56 percent less ozone reactivity. Propane-powered vehicles had 43 to 46 percent less CO and 57 to 61 percent better ozone reactivity. Reformulated Phase 2 gasoline was also cleaner with 13 to 17 percent less CO on two types of vans (it was, however, one percent worse than regular unleaded gasoline on Ford vans). RFG's ozone reactivity was 12 to 38 percent cleaner than regular unleaded gasoline.

The study also included two electric vehicles. EV emissions in the Southern California area are 98 percent cleaner than gasoline when including emissions from power plants.

The CleanFleet Project used vehicles with the best technology for the time (1992 model year vehicles), and future emission results with newer technologies are expected to be even better as these technologies advance and mature.



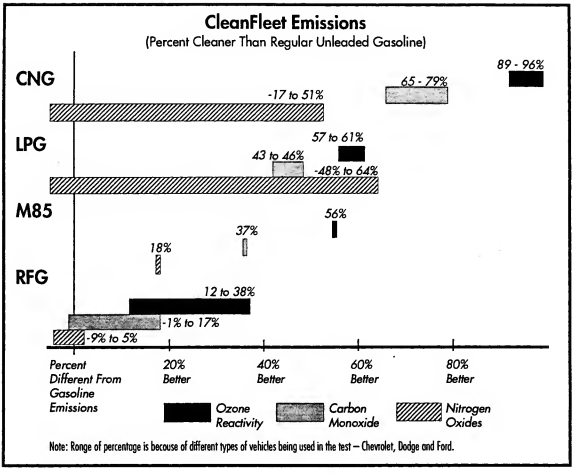
California's Sources of Oil

Energy Content of Alternative Fuels

Petroleum-based fuels (gasoline and diesel) offer excellent energy content by volume. By comparison, alternative fuels have less energy density. Hence, the fuels may have less mileage on a gallon to gallon basis than gasoline. On the next page is a chart that compares the energy density of the various fuels.

California's Involvement in Clean Alternative Fuel Vehicle Development

California has been at the forefront of developing clean, alternative fuels and vehicles. Since 1978, the Energy Commission has worked with auto makers, fuel providers and utility companies, universities and research institutes, and research and development companies to advance the state-of-the art in alternative



Comparison of Fuel Energy Content

Fuel	*Pressure*	*Btu/gal.*	*Ratio of Energy Content Compared to Gasoline*
Diesel		129,000	0.89 to 1
Gasoline		115,400	1.00 to 1
E85		105,545	1.09 to 1
Propane		82,485	1.40 to 1
Ethanol		75,000	1.54 to 1
LNG		73,500	1.57 to 1
M85		65,350	1.77 to 1
Methanol		56,500	2.04 to 1
CNG	@ 5845 psi	56,500	2.04 to 1
Liquid Hydrogen		34,000	3.39 to 1
CNG	@ 3000 psi	29,000	3.98 to 1
Hydrogen	@ 3000 psi	9,667	11.94 to 1

and efficient vehicles. In this endeavor, California has committed more than $130 million toward alternative fuels and vehicles. Most of this money has come from fines paid by oil companies from settlement of lawsuits for over-charging consumers at the pumps during the oil crises of the 1970s. The programs the Commission haves undertaken cover all aspects of vehicle and engine technologies.

1978 **California Begins Its AFVs Program** – Energy Commission begins its first alternative fuel vehicle demonstration program. VW Rabbits factory-built to run on ethanol and methanol were used in side-by-side tests. Early national emphasis was on domestic coal-derived synthetic fuels: shale oil, gasoline, methanol, hydrogen. Goals were for alternative fuels to be able to displace oil and meet California emissions standards.

1981 Commission creates a methanol demonstration fleet with Ford Motor Company and put a limited number of test methanol-powered vehicles on the road in 1981 and 1982.

1982 Commission funds the first two transit buses in country to run on methanol. The buses, named Methanol 1 and Methanol 2, operated in commuter service between Marin County and City of San Francisco. One vehicle is still in service in Ventura. The other is with the Riverside Transit Agency.

1983 500 "dedicated" methanol-powered Ford Escorts put into state and local government fleets. Vehicles gained 20 million miles of on-road experience. The fuel showed a 50% to 80% emission reduction potential. A handful of these vehicles are still in service in various city and county fleets.

1986

- Commission's Energy Technologies Advancement Program funds the retrofit of three diesel engines to methanol fuel in a $1.8 million project. Engines used in Riverside Transit Agency buses.

- Commission begins its Heavy-Duty Truck Demonstration Program with $700,000, augmented by additional funds later. This joint project was done with South Coast Air Quality Management District and five engine manufacturers: Caterpillar, Cummins, Detroit Diesel, Ford and Navistar. Vehicles placed at eight host sites included: water delivery truck, refuse haulers, dump trucks, sludge hauler, tractor/trailers and line truck.

1987

- Assembly Bill 234 directs the Energy Commission to study and report back to the Legislature on the cost and availability of low-emission fuels and vehicles.

- Ford announces Flexible Fuel Vehicle (FFV) technology – allows vehicles to run on methanol OR gasoline from a single tank. Ford produces Crown Victoria FFVs for demonstration fleet. A total of 217 Crown Victoria FFVs built between 1987 and 1989.

- Commission's ETAP project funds development of a hybrid electric vehicle. The $404,000 project done with Electric Auto Association and Stanford University. It converted a Chevrolet Corsica to a hybrid EV with gasoline-powered generator.

1988

- Safe School Bus Program is created by Assembly Bill 35, authored by Assemblyman Richard Katz. The program provides $100 million program in three phases to replace buses built prior to 1977 Federal Motor Vehicle Safety Standards. A minimum of 35% of vehicles must be powered by fuels other than petroleum-based. The three phases include:

  Phase 1 – 14 school districts and consortia are involved; 163 buses purchased: 103 advanced diesel, 50 methanol, 10 compressed natural gas. Buses delivered in 1989.

(1988 continued)

Phase 2 – 47 school districts and consortia are involved; 400 buses purchased: 200 advanced diesel, 100 methanol, 100 compressed natural gas. Buses delivered by fall of 1993.

Phase 3 – An estimated 150-200 buses will be purchased. Program Opportunity Notice went out to school districts in fall 1994. Buses to be delivered in 1996/1997.

- GM announces its own Variable Fuel Vehicle (running on M85) and builds 20 Chevrolet Corsica Variable Fuel Vehicles for use in State of California and air district fleets in demonstration programs.

- 1988 Alternative Motor Fuels Act passes Congress. It establishes Corporate Average Fuel Economy credits for AFVs produced by auto companies.

- Energy Commission establishes California Fuel Methanol Reserve. ARCO signs agreement with Energy Commission to establish M85 fueling stations at a number of its gasoline stations. Other oil companies 1988 (continued)

  follow: Chevron, Exxon, Mobil, Shell, Texaco and Ultramar. Commission signs contracts for 83 M85 facilities in California for ten-year demonstration program. First station opened in 1989 by then-Vice-President George Bush in Los Angeles.

- Commission funds ETAP project to develop medium-duty natural gas engine for UPS step-van in a $1.5 million project done with Acurex Corporation, Mountain View, Calif.

1989

- ARCO announces its first Reformulated Gasolines — EC1, EC Premium and eventually ECX. In 1990, ARCO says its ECX will be as clean as M85.

- Chevrolet delivers first of its Lumina Variable Fuel Vehicles to the Energy Commission. Eventually 265 of the Lumina VFVs are delivered to fleets in 1990. GM announces it will sell up to 2,000 Lumina VFVs in 1992.

1990

- Ford delivers 250 – 1991 Model Year Taurus Flexible Fuel Vehicles for demonstration in government/ private fleets and produces 183 Econoline Van FFVs for 1992.

- Clean Air Act passed by Congress: Establishes California Pilot Program requiring 150,000 clean fuel vehicles a year for California by 1996, increasing to 300,000 a year by 1999. Vehicles can run on reformulated gasoline (one of the federally-designated "clean" fuels). Allows other states to adopt California's LEV emission standards.

- California Air Resources Board Low Emission Vehicle and Clean Fuel Availability Regulations adopted September 1990. Requires ZEVs to be offered for sale in 1998.

1991

- Chrysler, with the Commission at its news conference, announces it will produce up to 2,500 Plymouth Acclaims and Dodge Spirits FFVs to run on methanol in 1992 Model Year. They offer the flexible fuel option at no extra cost above a gasoline vehicle. Other auto companies follow suit.

(1991 continued)

- Commission's Electric Vehicle Demonstration Program begun in partnership with Pacific Gas and Electric Company. The project will demonstrate three Conceptor G-Van EVs in a three-year program. Vans used by Cities of Oakland and Santa Rosa for mail delivery and in Yosemite National Park. Total of $60,000 from Commission and $60,000 from PG&E.

- Advanced Technology EV Demo Program announced by the Commission. Contract Opportunity Notice sent to 250 manufacturers of EVs, hybrids, developers and others, with responses received from 20 companies. Four companies chosen that met performance specifications, and a total of $692,000 from Commission plus money from air districts and other governmental agencies was devoted to the projects. These included:

  - ☞ Chrysler TEVan - Four purchased with either Nickel-Cadmium or Nickel-Iron batteries
  - ☞ Ford Ecostar - Seven purchased with Sodium Sulfur batteries
  - ☞ Solectria Force - Four purchased with Advanced Lead-Acid
  - ☞ Volkswagen Jetta/Golf EV - VW decides later to withdraw

1992

- Commission funds CALSTART. The consortium is made up of aerospace, auto, electronic and computer companies; universities and colleges; and government agencies — more than 80 members. A total of $2 million was committed by the California Energy Commission to match $4 million in federal support and more than $20 million in private capital. The consortium's goal is to establish an advanced transportation technologies industry in California. CALSTART produces a Showcase EV (using components from California companies) for display at international auto shows and other projects.

- Light-Duty Natural Gas Vehicle Demonstration Program: Commission pays for half of differential cost of equipping 100 GMC and Chevrolet 1992 model year 3/4-ton as dedicated natural gas pickup trucks. They were placed into service in ten fleets around the state (out of about 200 NGV trucks sold). The five-year demonstration program ended early, however, after all trucks were recalled in 1994 due to bad CNG cylinder design following two tank ruptures (San Francisco and Minnesota).

- Project with Vons Companies Inc. (California's largest supermarket company), Ford, National Renewable Energy Laboratory, SoCal Gas, SCAQMD places a heavy-duty natural gas-powered truck on the road. The project uses a Ford LTLA-9000 "Aeromax" tractor with Caterpillar G3406 engine. Pulled trailer between El Monte and Bakersfield over the "Grapevine" and the 4,183-foot Téjon Pass. It is the country's first long-haul CNG-fueled truck with an OEM engine.

1993

- NGV Demonstration Program – Cost-sharing with utility companies to purchase equipment for 40 vehicles. Vehicles placed with: City of Ontario – five B-350 Dodge RAM Vans for rideshare program; County of Sacramento – five GMC Sierra pickup trucks for County Dept. of Public Works; and VPSI Commuter Vanpools – 30 Dodge B-350 RAM Vans for use in Orange County.

- Commission creates the Transportation Energy Technologies Advancement Program (TETAP) and funds research by California companies in a number of areas. Including:

  - ☞ $66,666 toward medium-duty CNG engine for delivery vehicles with Aucurex Environmental in Mountainview, Calif.
  - ☞ SMUD Advanced Flywheel Project: $4 million project with American Flywheel & Honeywell Systems.
  - ☞ CALSTART Electric School Bus: $1 million project to retrofit two diesel buses to electricity and build one "ground-up" bus.

(1993 continued)

- ☞ Hughes Electric Shuttle Bus: $580,000 project to place an advanced 30-foot EV bus at LAX. The project was later withdrawn by Hughes.
- ☞ GM Impact PrEView Program: $500,000 from Energy Commission toward program that will "loan" GM Impacts to 1,000 drivers around U.S. for two to four weeks. Delivery of first group of Impacts was in Los Angeles, June 23, 1994. Cars will be tested in L.A., Sacramento, San Diego and San Francisco and eight other cities across country.
- ☞ Cummins Engine: $977,000 project to develop advanced turbocharger for a diesel engine.

- Commission Diesel Emission Reduction Fund Program begins using fine money collected from polluting heavy-duty vehicles. Projects funded in this first year include:

  - ☞ Cal State Fresno, $19,672 – using water injection to clean diesel exhaust
  - ☞ Cummins Engine, $480,000 project – development of low-cost particulate trap

- CE – CERT Advanced Transportation Research & Testing: Energy Commission gives $1,400,000 toward University of California, Riverside's College of Engineering – Center for Environmental Research and Technology (CE – CERT). CE-CERT is a $125 million research center also funded by Energy Commission, technology reinvestment funds, U.S. Department of Energy, auto industry, etc. Its primary research areas include: atmospheric processes, vehicle emissions, environmental modeling, transportation systems, advanced vehicle engineering, renewable fuels, manufacturing processes and stationary source emissions.

1994

- Alternative Fuel Vehicle Demonstration Program in Yosemite National Park created by Senate Bill 314, authored by State Senator Dan McCorquodale. In cooperation with National Park Service, Caltrans, local transit companies and Pacific Gas and Electric Company, the Energy Commission awards $640,000 for projects in the park:

  - ☞ Yosemite Electric Bus Program: Park's concessionaire operates ten diesel powered buses in Yosemite Valley, carrying three million visitors a year. The program replaces diesel buses with electric buses. In 1995, three or four electric buses to be put into service in a three-year demonstration program. Total Cost: $1.47 million ($500,000 from Commission).
  - ☞ Yosemite Natural Gas Tourist & Transit Buses: VIA Adventures undertakes a $350,000 project to convert up to four buses to compressed natural gas. These buses provide daily transit service from San Joaquin Valley and Amtrak connector service to Yosemite. California Yosemite Tours does a $775,000 project to covert five transit buses to CNG for daily transit service from Fresno to Yosemite and Sequoia /Kings Canyon.

- Commission TETAP funds six more projects:

  - ☞ Amerigon – Advanced Heating/Cooling System for EVs - $675,000 project.
  - ☞ APS Systems – Advanced EV Shuttle & Paratransit Buses - $440,000 project.
  - ☞ CALSTART – Hybrid EV / Natural Gas, 40-foot Transit Bus - $1.1 million project.
  - ☞ Pinnacle Research Institute – Ultra-Capacitor for EVs and Hybrids - $690,000 project
  - ☞ U.S. Electricar – Conversion to electricity of Grumman "Long Life" U.S. Postal Service Delivery Trucks - $855,000 project with six Post Office EVs split between Torrance, California, and USPS Headquarters in Merrifield, Virginia.
  - ☞ Dyna-Cam - $607,569 toward development of 210 hp Dyna-Cam Aero Engine to run on compress natural gas. Project suspended in late 1994.

- Medium-Duty NGV Program - $600,000 from Commission and $174,000 from natural gas utilities (PG&E, SoCal Gas, SDG&E, Long Beach Gas) funds 54 natural gas vehicles in diverse range of uses:

(1994 continued)

package delivery trucks, dump trucks, shuttle buses, "trolley" buses, tow truck, utility crew trucks. Ten public and private fleets participating, including: Cities of Chula Vista, Long Beach, Ontario and Whittier; Monterey County; Sacramento Metro Airport; United Parcel Service of Los Angeles; Dydee Diaper; Center City Towing in San Diego.

- 1994 demo project with The Los Angeles Times/Times Mirror Company, SCAQMD, SoCal Gas, National Renewable Energy Laboratory (NREL), American Trucking Association Foundation (ATAF) to demo a heavy-duty natural gas truck. The project uses a Ford LTLA-9000 "Aeromax" tractor using Detroit Diesel Corporation Series 60-G, 370 horsepower engine using CNG. The truck travels an interurban route between Orange County and downtown L.A.

- Project with Los Angeles County Sanitation District, SCAQMD, SoCal Gas, NREL and ATAF to demo a heavy-duty natural gas truck. The truck is a Freightliner tractor using Detroit Diesel Corporation Series 60-G 370 horsepower engine. The vehicle will be powered by Cleaned Landfill Gas (or CLG, which is mostly methane given off by decomposition at landfills).

- Diesel Emission Reduction Fund: two projects funded
  - ☞ CeraMem Corp., $300,000 project – Exhaust Gas Recirculation and particulate filter
  - ☞ Southwest Research Institute, $1 million project – Direct and indirect injection systems

Deciding Which Fuels Are Best You or Your Fleet

When determining what type(s) of fuels to use, private vehicle owners and fleet managers should weigh all the factors: economics; which models are available; rebates and incentives offered by auto companies, government and utilities; ease of refueling; whether you'll install a fueling facility on your own property; whether to have a dedicated vehicle or a bi-fuel vehicle; distances cars will need to travel; trade-in value; maintenance; etc. One fuel might be perfect for one application, but that same fuel might not be good for another.

This booklet will help you with the basic information on each of the different fuels. If you need additional general help in determining what kind of alternative fuel vehicle you should purchase please contact the following. There are listings at the end of each chapter for specific contacts on various fuels.

General Information
California Energy Commission
Transportation Technology & Fuels Office
1516 Ninth Street, MS-41
Sacramento, CA 95814
(916) 654-4634

Compressed Natural Gas
California NGV Coalition
925 L Street, Suite 1485
Sacramento, CA 95814
(916) 448-5036

Electric Vehicles
California Electric Transportation Coalition
1303 J Street, Suite 770
Sacramento, CA 95814
(916) 552-7070

Ethanol-Powered Vehicles
California Renewable Fuels Council
3304 Yorba Linda Blvd., Suite 249
Fullerton, CA 92631
(714) 996-6540

Propane-Powered Vehicles
LPG Clean Fuels Coalition
2102 Business Center Drive, Suite 130
Irvine, CA 92714
(714) 253-5757

General Information
National Alternative Fuels Hotline
P.O. Box 12316
Arlington, VA 22209
(800) 423-1DOE (1363)

Chapter 2

Laws, Regulations and Requirements Affecting Alternative Fuel Vehicles

There are three main laws and regulations that relate to alternative fuels and the vehicles that use those fuels: the federal 1990 Clean Air Act Amendments, the 1992 National Energy Policy Act, and the 1990 California Air Resources Board's Low Emission Vehicle Requirements. Additional regulations that may affect businesses and fleets have been approved at state and local levels by the Legislature and various air quality districts. This chapter will look at the policies and also at incentives offered for AFVs.

Federal Laws

The **Clean Air Act Amendments (CAAA)** of 1990 (Public Law 101-549) was passed by Congress to amend the original Clean Air Act from 20 years earlier. The Amendments include provisions that require gasoline refiners to reformulate their gasolines to meet more stringent emission standards. In cities that do not meet federal air quality requirements set forth in the 1990 Amendments, gasolines must be reformulated during certain months, when carbon monoxide and ozone pollution are most serious. The regulations also require certain fleet operators to use clean fuel vehicles in 22 metropolitan areas nationwide. The clean fuels included the use of reformulated gasoline and many alternative fuels.

The CAAA also established the California Pilot Program requiring 150,000 clean fuel vehicles a year for California by 1996, increasing to 300,000 a year by 1999. Vehicles can use reformulated gasoline (one of the federally-designated "clean" fuels). The law allows other states to adopt California's Low Emission Vehicle standards.

Prior to the CAAA, Congress passed the Alternative Motor Fuels Act of 1988 – AMFA (Public Law 100-494), which encouraged the development, production and demonstration of alternative motor fuels and alternative fuel vehicles. That law, however, did not affect fleets. It did establish Corporate Average Fuel Economy (CAFE) credits for auto companies producing AFVs.

The **National Energy Policy Act of 1992 (EPAct)** is Public Law 102-486. The broad-ranging act was signed into law by President Bush on October 24, 1992. Several titles deal with alternative transportation fuels. For alternative transportation fuels, EPAct:

- Accelerates the purchase requirements for alternative fuel vehicles by the federal fleet. The numbers were increased further by Executive Order12844 signed by President Clinton (see footnotes on page 16).
- Proposes a cap on credits that auto manufacturers can earn by producing dual-fuel and flexible fuel vehicles
- Requires fleets in large urban areas to purchase not only clean fuel vehicles but vehicles that use alternative fuels

EPAct also establishes tax incentives for purchase of alternative fuel vehicles and conversion of conventional gasoline vehicles to alternative fuels by the private sector. The chart on the following pages gives a comparison between the major provisions of the two federal laws.

California Regulations

California's geography, climate and number of vehicles create California's unique smog problems. Major urban areas of the state are surrounded by mountains that trap pollution in stagnant air. Persistent stagnant weather conditions during much of the year not only prevent pollution from dispersing in the atmosphere, but also increase the amount of time pollutant gases are exposed to sunlight, which prompts the chemical reactions that create smog.

In September 1988, Governor George Deukmejian signed the California Clean Air Act, Assembly Bill 2595, authored by Assemblyman Byron Sher. The Act defined an framework for air quality planning and regulations, establishing a new means for reaching California's air quality goals.

(Text continues on page 17.)

Provision	Clean Air Act Amendments of 1990	National Energy Policy Act of 1992
Persons Affected	Public or private fleet owners or operators with 10 or more vehicles capable of being centrally fueled. Note: California fleets are exempt.	"Persons" who own, operate, lease or control at least 50 vehicles in the U.S. (centrally fueled or capable of being centrally fueled), primarily operated in a Consolidated Metropolitan Statistical Area (CMSA) with a 1980 population of 250,000 or more.
Areas Affected	22 metropolitan areas with a 1980 populations of 250,000 or more and designated by the U.S. EPA as in severe or extreme non-attainment of either ambient ozone or carbon monoxide standards (See List A below). Other areas may "opt-in" to the program per state air quality attainment strategy (no others areas have done so through mid-1994).	More than 120 cities with a 1980 population of 250,000 or more (See List B below for California cities.)
Fleet Definition	10 or more light-duty or heavy-duty vehicles located in the affected area.	Fleets of 20 or more light-duty vehicles, less than 8,500 pounds gross vehicle weight capable of being centrally fueled that are owned, operated, leased or controlled by a government entity or by another person who controls 50 or more such vehicles.
Effective Dates	Begins in 1998 (See List C below.)	1993 (federal fleets 1996 (state fleets) 1996 ("fuel providers") 1999 (municipal/private) 2002 (municipal/private by DOE rule) (See List C below.)
Purchase Requirements	Clean Fuel Vehicle (CFV) Fleet Program (See List C below).	There are requirements for federal, state, fuel providers, municipal and private fleets. (See List C below.)
Fuel Definition	Clean Fuels including: • Methanol (M85) • Ethanol (E85) • Other alcohols • Reformulated gasoline • Clean Diesel • Natural gas • Liquefied petroleum gas (LPG)	Alternative Fuels including: • Methanol • Ethanol • Other alcohols, separately or in mixtures of 85% by volume or more (but not less than 70% volume by rule) with gasoline or other fuels • Compressed natural gas (CNG) • LPG • Hydrogen • "Coal-derived liquid fuels" • Fuels derived from "biological materials"

Provision	Clean Air Act Amendments of 1990	National Energy Policy Act of 1992
Fuel Definition (continued)	• Electricity • "Any other power source" able to meet California vehicle emissions standards.	• Electricity • Any other fuel "substantially not petroleum" yielding "substantial energy security benefits and substantial environmental benefits." Reformulated gasoline may not be used to meet EPAct requirements.
Credits	Provides credits for CFV fleets. (California fleets are not covered.) Emissions reduction credits available for CFVs that are exempt from requirements, purchased in advance or requirement, or purchased in excess of minimum requirement. Credits can be transferred, "banked" or used to offset new sources within the same non-attainment area.	Credits earned if AFVs are acquired in excess of minimum required or in advance of date of requirement at the rate of one credit per vehicle. Credits earned are transferable from one area to another.
Buses	**Bus Requirements** All buses initially in cities with populations of 750,000 or more would be operated on "clean fuels" (phased-in starting in 1994). Urban bus retrofit regulations are effective beginning in 1995. They will require buses to be retrofitted according to a schedule and meet stricter emissions standards, including a minimum reduction in particulates of 25%, either on a per-vehicle or fleet average basis. **Bus Retrofit Requirements** Effective in 1995, new emissions requirements for rebuilt, heavy-duty diesel-engine urban buses will be applicable to model year 1993 or earlier. There is a 0.10 gram/bhp-hr (maximum) particulate mater (PM) emissions limit in cities with a population of 750,000 or more.	**Bus Demonstrations** **Urban Buses:** The Department of Transportation (DOT) and Department of Energy (DOE) shall initiate cooperative ventures with local governments with populations of 100,000 or more to demonstrate the feasibility of commercializing the use of alternative fuels. **School Buses:** DOT may provide financial assistance to local units of government (in urban areas with populations of 100,000 or more) to cover the incremental costs of operating and purchasing buses using alternative fuels, including vehicle conversions.
Off-Road Engines	US EPA is preparing to propose regulations to control emissions (NOx and PM) from heavy-duty (and other) engines used in off-road applications, including farm equipment, marine engines and locomotives.	US DOE is required to "conduct a study" to determine the effectiveness of using alternative fuels in off-road vehicles in "surface transportation" such as rail, airport vehicles, marine engines and others.

Provision	Clean Air Act Amendments of 1990	National Energy Policy Act of 1992
Tax Incentives	No provisions.	Maximum tax deductions are provided as follows for the incremental costs of AFVs (including retrofits) and refueling facilities placed in service after June 30, 1993: AFVs up to 10,000 lb. gvw: up to $2,000 AFVs 10,001 - 26,000 lb. gvw: up to $5,000 Trucks/Vans (over 26,000 lb gvw): $50,000 Buses with seating capacity of 20 or more adults: $50,000 Electric Vehicles: 10% tax credit up to $4,000/vehicle AFV Refueling Facility: $100,000
Biodiesel Study	Study on "alcohol esters of rapeseed oil" concerning its "feasibility, engine performance, emissions and production capability."	No provisions.
"Replacement Fuels"	No provisions.	The portion of a motor fuel that is methanol, ethanol, or other alcohol, CNG, LPG, hydrogen, coal-derived liquid fuel, fuel "other than alcohol" derived from "biological materials," electricity, and ethers. U.S. DOE may determine by rule that any other fuel that is "substantially not petroleum" and yielding "substantial energy security benefits and substantial environmental benefits" will qualify as a replacement fuel. **National Petroleum Reduction Targets:** By 2000: 10% replacement By 2010: 30% replacement

List A
Areas Covered in Clean Air Act Amendments of 1990
(Clean-Fuel Vehicle Fleet Program)
California Cities/Regions in Bold

Los Angeles-Anaheim-Riverside, CA
Sacramento, CA
San Diego, CA
San Joaquin Valley, CA
Southeast Desert, CA
Ventura County, CA

Atlanta, GA
Baltimore, MD
Baton Rouge, LA
Beaumont-Port Arthur, TX
Chicago-Gary-Lake County, IL-IN-WI
Denver-Boulder, CO
El Paso, TX
Greater Connecticut, CT
Houston-Galveston-Brazoria, TX
Milwaukee-Racine, WI
New York-Long Island-Northern Jersey, NY-NJ
Philadelphia-Wilmington-Trenton, PA-DE-MD-NJ
Providence-Pawtuckett-Fall River, RI-MA
Springfield, MA
Washington, DC Area, MD-VA-DC

List B
EPAct-Affected Areas in California
Metropolitan Areas of California with a
1980 Population of 250,000 or More

Bakersfield
Fresno
Los Angeles-Anaheim-Riverside
Modesto
Sacramento
Salinas-Seaside-Monterey
San Diego
San Francisco-Oakland-San José
Santa Barbara-Santa Maria-Lompoc
Stockton

List C
Comparison of New AFV Purchase Requirements For Affected Vehicle Fleets

	Clean Air Act	National Energy Policy Act of 1992				
Year	(% of CFVs) Percentages Do Not Apply to California Fleets	Federal (% or # of AFVs)	State (% of AFVs)	Fuel Provider (% of AFVs)	Municipal & Private Early Rule (% of AFVs)	Municipal & Private Late Rule (% of AFVs)
1993		5000/7,500+				
1994		7500/11,250+				
1995		10000/15,000+				
1996		25%/17,500+	10%/25%‡	30%		
1997		33%/20,000+	15%/33%‡	50%		
1998	30%	50%/30,000+	25%/50%‡	70%		
1999	50%	75%/40,000+	50%/75%‡	90%	20%	
2000	70%	75%	75%‡	90%	20%	
2001	100%	75%	75%	90%	20%	
2002	100%	75%	75%	90%	30%	20%
2003	100%	75%	75%	90%	40%	40%
2004	100%	75%	75%	90%	50%	60%
2005	100%	75%	75%	90%	60%	70%
2006	100%	75%	75%	90%	70%	70%

* Under the National Energy Policy Act, the U.S. Secretary of Energy has two opportunities to rule on AFV purchases for private fleets. If a rulemaking is issued by December 16, 1996, then the percentages in the "early rule" column apply. If a rulemaking is not issued until later (January 1,.2000 deadline), then the percentages in the "late rule" column apply.

+ Federal fleet purchases were changed by Executive Order 12844 signed by President Bill Clinton in February 1993. This increases federal purchases (if vehicles are available from auto companies) to 7,500 in 1993; 11,250 in 1994; 15,000 in 1995; 17,500 in 1996; 20,000 in 1997; 30,000 in 1998; and 40,000 in 1999. Purchase percentages are based on about 50,000 vehicle acquisitions per year and vehicle turn-over/ replacement after five years.

‡ Percentage of AFVs required by State of California were increased by Executive Order No. W-100-94, signed by Governor Pete Wilson on August 15, 1994. The Executive Order requires: 25% of vehicles purchased in 1996 be AFVs; 33% be AFVs in 1997; 50% be AFVs in 1998; and 75% be AFVs in 1999 (if vehicles are available from manufacturer and at a reasonable cost). The order also requires that 10 percent, inclusive, must be Ultra-Low Emission Vehicles or Zero-Emission Vehicles in 1996 and beyond.

Under the act, the California Air Resources Board (CARB) set new car standards of 0.4 grams/mile of Nitrogen Oxides (NOx) for passenger vehicles beginning with the 1989 model year. In 1993, the standards became more stringent, requiring manufacturers to meet a 0.25 gram/mile standard for hydrocarbons and 3.4 grams/mile for carbon monoxide for all passenger vehicles and light-duty trucks (see chart).

Because of the enormity of its air pollution problems, California was allowed under the federal Clean Air Act Amendments of 1990 to continue to set its own standards for vehicle emissions. The law also allowed other states to use either the national standards, or they could opt for California's stricter standards; they could not create a third set of standards. Two states (New York and Massachusetts) have already done so, with Zero Emission Vehicle requirements going into effect in 1999, and 10 other states plus the District of Columbia (the Northeast Ozone Transport Committee) was awaiting approval (as of this writing) from the U.S. EPA to follow California's lead.

In September 1990, regulators at CARB adopted vehicle and fuels requirements, as well as a "reactivity protocol" for various clean fuels. It also took the unprecedented step of requiring a phase-in of even stricter emissions standards in California, including the first-ever provision for Zero Emission Vehicles (ZEVs). The Board set four levels of low-emission vehicles: Transitional Low Emission Vehicles, Low Emission Vehicles, Ultra-Low Emission Vehicles and Zero Emission Vehicles. The percentages of progressively cleaner vehicles are to be increased and phased-in over a ten-year period. The emissions levels could be reached by changes in fuel (either to reformulated or alternative – fuel neutral) or in the vehicle itself (such as better catalytic converters).

CARB's Low Emission Vehicle Regulations affect major auto manufacturers that sell 35,000 or more cars a year in California (Chrysler, Ford, General Motors, Honda, Mazda, Nissan and Toyota). The regulation requires that of the vehicles offered for sale in 1998 and beyond, a set percentage of them must be zero (tailpipe) emission vehicles. The only vehicles that currently qualify as ZEVs are electric vehicles.

The regulation was upheld by CARB in May 1994, when the Board reaffirmed its time table for implementation and noted that technical advances were on track. The regulation will be reviewed by CARB in 1996.

In August 1994, Governor Pete Wilson issued an Executive Order to increase the number of AFVs pruchased for California's state fleet use. The order increased the percentage of vehicles as much as 25 percent more than what the National Energy Policy Act required. (See footnote on previous page.)

In addition to the CARB regulations, various state laws have been passed that focus on clean, alternative fuels and AFVs.

Some of the more recent bills from both the state Senate (Senate Bill – SB) and Assembly (Assembly Bill – AB) are listed below. The bill number is followed by the author's last name and its enrollment citation.

- AB 234 (Leonard, Chapter 1326, Statutes of 1987) Defines Low Emission Vehicle, requires that the California Energy Commission study the cost and availability of low emission fuels and vehicles. Report issued in 1989 and updated in 1991 titled: *AB 234 Report – Cost & Availability of Low-Emission Motor Vehicles and Fuels*, Energy Commission publication number P500-91-009.

CARB Low Emission Standards for Passenger Cars & Light-Duty Vehicle

Emissions for 50,000 and 100,000 miles in Grams Per Mile

	NMOG		*CO*		*NOx*	
	50,000	100,000.	50,000	100,000	50,000	100,000
1993 Standards	0.25	0.31	3.4	4.2	0.4	0.6
TLEV	0.125	0.156	3.4	4.2	0.4	0.6
LEV	0.075	0.90	3.4	4.2	0.2	0.3
ULEV	0.040	0.055	1.7	2.1	0.2	0.3
ZEV	zero		zero		zero	

Note: NMOG = Non-Methane Organic Gases, CO = Carbon Monoxide, NOx = Nitrogen Oxides; TLEV = Transitional Low Emission Vehicle, LEV = Low Emission Vehicle, ULEV = Ultra-Low Emission Vehicle, ZEV = Zero (tailpipe) Emission Vehide. Emissions in grams per mile are allowed to increase as the car ages from 50,000-100,000 miles.

California Air Resources Board Low Emission Vehicle Fleet Average Goals

Model Year	*Conventional Standard*	*TLEV*	*LEV*	*ULEV*	*ZEV*
1993	40%				
1994	80%	10%			
1995	85%	15%			
1996	80%	20%			
1997	73%		25%	2%	
1998	48%		48%	2%	2%
1999	23%		73%	2%	2%
2000			96%	2%	2%
2001			90%	5%	5%
2002			85%	10%	5%
2003			75%	15%	10%

Note: Only the ZEV percentages are mandated. The others are potential percentages that the auto companies can use as goals.

- SB 1123 (Leonard, Chapter 796, Statutes of 1989) Amends the definition of LEV; requires state fleet purchases of AFVs if vehicles and funds are available.
- SB 1006 (Leonard, Chapter 990, Statutes of 1989) Exempts the "incremental cost" of LEVs from the state sales tax. (Expired December 31, 1994. See incentives below.)
- SB 2600 (Vuich, Chapter 1611, Statutes of 1990) Allows a state income tax credit for LEV purchases and conversions (amended by Senate Bill 146 in 1993). (See incentives below.)
- AB 434 (Sher and Cortese, Chapter 807, Statutes of 1991) Allows Bay Area Air Quality Management Districts to collect a surcharge (up to four dollars) through local vehicle registrations to pay for air quality improvement programs in their district and to reduce air pollution from motor vehicles. These fees have been used to help fund various local district incentive programs for alternative fuel vehicles, ridesharing and fleet/employee trip-reduction programs, clean fuel buses, feeder buses/shuttle service, and other projects.
- SB 135 (Boatwright, Chapter 496, Statutes of 1991) Effective January 1, 1997, requires public vehicles operated for compensation — transit vehicles and taxis — in districts not achieving air quality standards to meet CARB's low emission standards
- SB 1214 (Killea, Chapter 900, Statutes of 1991) Requires the California Energy Commission to forecast transportation energy demand. Staff report issued in February 1994 titled: *1993-1994 California Transportation Energy Analysis Report*, Energy Commission publication number P300-94-002, Docket No. 92-TFER-1.
- AB 3052 (Polanco, Chapter 762, Statutes of 1992) Requires the California Energy Commission to develop an infrastructure master plan for alternative transportation fuels – the CalFuels Plan. Report issued in September 1994 titled: *CalFuels Plan – Developing an Infrastructure Plan for Alternative Fuel Vehicles*. Energy Commission publication number P500-94-002.
- AB 35 (Klehs, Chapter 873, Statutes of 1993) Conforms the state income tax credit for low emission vehicles to reflect

the allowable federal tax credit for electric vehicles in the National Energy Policy Act.

- SB 146 (Lewis, Chapter 875, Statutes of 1993) Expands the LEV tax credit to non-recreational off-road vehicles; extends the sunset on state low emission vehicle tax credit from January 1, 1995, to January 1, 1998; and deletes the sunset on the Use Fuel Tax Law provisions that sets the fuel tax rate for methanol and ethanol at one-half the rate for gasoline and diesel fuels.
- SB 316 (Rosenthal, Chapter 956, Statutes of 1993) Existing law allows the South Coast Air Quality Management District to impose a vehicle registration surcharge to fund clean fuel and alternative fuel vehicle programs. SB 316 extends the sunset on the surcharge to August 1, 1999, and eliminates the sunset on the program.

Local Air District Regulations

Local air quality districts can pass and enforce local air quality ordinances or regulations that will effect fleets, businesses and individuals. A number of districts have passed regulations affecting fleets. Below is a summation of the various regulations and incentives that are currently in force in four of the state's urban areas. Fleet managers are advised to contact their local air quality district for additional information. Those who do not live in a multi-county district shown in the map, should contact your local county's air pollution control officer — the number should be listed in the government listings of your phone book.

Bay Area Air Quality Management District (BAAQMD)

The BAAQMD requires large companies to develop a trip-reduction program or an Alternative Emission Reduction Program (AERP), which is updated every two years. The AERP can include clean fuel vehicles in employer fleets (either new or retrofit) or clean fuel buses (transit buses, school buses or shuttles). The employer must demonstrate, however, that the clean fuel vehicles are not being used by the vehicle manufacturer to fulfill the state LEV/ZEV requirements or by the employer to comply with any clean fuel vehicle fleet rule (such as under the National Energy Policy Act).

Public agencies and their fleets can request funding for clean fuel buses and demonstration projects using alternative fuel vehicles through the AB 434 Transportation Fund for Clean Air. This program applies only to public agencies including, but not limited to cities, counties, school districts, transit districts, and regional and state agencies. The BAAQMD places a high priority on projects funded through AB 434. About $17 million is generated annually from the surcharge and used toward these programs.

Sacramento Metropolitan Air Quality Management District (SMAQMD)

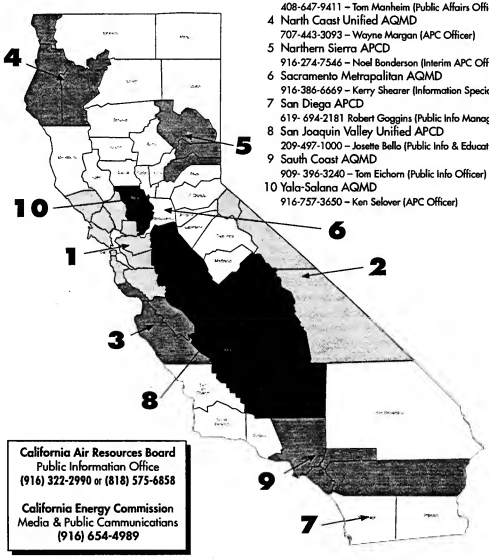
The SMAQMD has a rule that affects fleets with 15 or more vehicles in the district. Fleets are required to reduce emissions when they add or replace vehicles, when they replace a vehicle's engine, or when they rebuild an engine. It is up to the fleets to determine how they will reduce the vehicle's emissions — the rule is "fuel neutral" and is based on tailpipe emissions not on use of alternative fuels.

Fleets that purchase low emission vehicles can get credits for LEVs that are purchased above their required number. Fleets purchasing alternatively-fueled vehicles can get additional credits above the LEV credits. These credits can then be traded with other businesses in the district or to fleets considered by the district to be "under-achievers."

SACRAMENTO METROPOLITAN

AIR QUALITY
MANAGEMENT DISTRICT

Multi-County and Major Air Quality Management and Air Pollution Control Districts in California



Public Information Contacts

1 Bay Area AQMD
415-771-6000 – Terry Lee (Dir. of Public Information)
2 Great Basin APCD
619-872-8211 – Ellen Hardebeck (APC Officer)
3 Manterey Bay Unified APCD
408-647-9411 – Tom Manheim (Public Affairs Officer)
4 North Coast Unified AQMD
707-443-3093 – Wayne Morgan (APC Officer)
5 Northern Sierra APCD
916-274-7546 – Noel Bonderson (Interim APC Officer)
6 Sacramento Metropalitan AQMD
916-386-6669 – Kerry Shearer (Information Specialist)
7 San Diego APCD
619- 694-2181 Robert Goggins (Public Info Manager)
8 San Joaquin Valley Unified APCD
209-497-1000 – Josette Bello (Public Info & Education Officer)
9 South Coast AQMD
909- 396-3240 – Tom Eichorn (Public Info Officer)
10 Yolo-Solano AQMD
916-757-3650 – Ken Selover (APC Officer)

California Air Resources Board
Public Information Office
(916) 322-2990 or **(818) 575-6858**

California Energy Commission
Media & Public Communicatians
(916) 654-4989

SMAQMD currently has a number of incentive programs in place or planned for the near future. These include:

1. Methanol fuel incentive — The SMAQMD provides $500 of M85 to purchasers of Flexible Fuel Vehicles (FFVs). The FFV purchaser must either live in Sacramento County or operate the vehicle in Sacramento County at least 75 percent of the time in order to qualify. The fuel is provided through public access fueling network by issuing a $500 credit to the purchaser's account with Chevron, which manages the retail fuel network billing system.
2. The SMAQMD is developing a cost-sharing matrix that would provide incentives for light- and medium-duty vehicles based on their air quality benefits. This matrix is still in its formative stages and is contingent of the District's Board of Director's approval. If approved, it is expected to be in place by March or April 1995.
3. The SMAQMD has a continuous filing policy for unique and/or innovative alternative fuel projects. These projects are reviewed by the District as they are received. Their is no formal application other than to contact the SMAQMD with proposals.

South Coast Air Quality Management District (SCAQMD)

Rule 1501 was adopted by the SCAQMD in 1987 to encourage carpooling, use of public transit and other forms of ridesharing as a means to reduce auto emissions. Under the program, originally known as Regulation XV, employers of 100 or more employees are to provide their employees with incentives to rideshare. The original measure provided credits to employers whose employees used alternative fueled vehicles in their daily commute.

A subcommittee for the SCAQMD has proposed that the sunset date on the credits be eliminated (rule language is pending on that provision). Another proposal would equate a zero emission vehicle as being a zero vehicle trip in the AVR credits. That rule is in draft form.

Finally, according to the SCAQMD, all basin fleets may be required under the U.S. Environmental Protection Agency's Federal Implementation Plan (FIP) to purchase many more alternative fuel vehicles than are what are required under the National Energy Policy Act. The FIP would be put into place if the EPA does not agree with the way California and its air districts have drafted their own clean air plans, called the State Implementation Plan or SIP.

Under the FIP, 50 percent of the basin fleets' new car purchases would have to be Inherently Low Emission Vehicles (ILEVs) in 1999. That increases to 70 percent ILEVs in the year 2000 and beyond. ILEVs are any vehicle that is certified to meet the California Air Resources Board's Transitional Low Emission Vehicle standards and does not emit any evaporative emissions.

San Diego County Air Pollution Control District (APCD)

On November 29, 1994, the San Diego County Air Pollution Control District Board of Directors approved a new rule enabling industry to offset new or increased emissions from stationary sources with emission reductions from mobile sources. Because of declining potential for offsets from the region's stationary sources, the APCD Board recognized there was substantial demand for cost-effective credits from mobile sources. Motor vehicles contribute more than 60 percent of the smog-forming emissions in the San Diego air basin, and industry contributes less than 15 percent.

Rule 27 allows emission reduction credits from motor vehicles to be registered as "credits" in a District "Bank." Industry can withdraw or purchase these credits later to meet state and federal Clean Air Act offset requirements.

The rule specifies five ways mobile source emission credits can be created, including:

- Accelerating vehicle retirement (scrapping program)
- Purchasing low-emission transit buses (primarily compressed natural gas)
- Purchasing zero emission (electric) vehicles
- Retrofitting cars, and light- and medium-duty trucks to meet low-emission standards
- Retrofitting heavy-duty vehicles to meet low-emission standards

The rule also provides for other innovative technologies that create valid mobile source emission reductions.

The APCD currently has a program with a private contractor to purchase and scrap 1,000 pre-1982 vehicles. As of December 1994, the program is roughly 60 percent completed and should end in early 1995. If the market dictates, Rule 27 provides a mechanism to continue the program under private funding.

San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD)

REMOVE is the acronym that stands for "Reduce Motor Vehicle Emissions," a program of the SJVUAPCD, which serves Fresno and the Valley portions of Kern, Kings, Madera, Merced, San Joaquin, Stanislaus and Tulare Counties. The program was formerly known as "AB2766."

REMOVE is an innovative program that allocates fees collected from motor vehicle registrations for local projects designed to reduce air pollution. These funds must be applied to projects that reduce emissions from automobiles, trucks and buses. More than 280 proposals have been considered for funding by the SJVUAPCD since the inception of the program, with more than 90 projects funded from 1992 to 1994.

The SJVUAPCD Governing Board created a committee of 14 citizens to evaluate and recommend projects for funding. The evaluation committee for the REMOVE program develops criteria for evaluating proposals. The committee also rates and ranks the proposals and makes project funding recommendations to the Governing Board. The Board then makes final funding decisions.

Local government agencies, private sector businesses non-profit agencies and research institutions are among those eligible to apply for funding. Anyone proposing an effective project to reduce emissions from motor vehicles is encouraged to apply. In December 1994, requests for proposals (RFP) were made available for applicants to apply for the third annual cycle of funding. To receive an RFP, call the District at 209-497-1075.

As required by state law, the fees for the REMOVE program are collected by the California Department of Motor Vehicles and provided to the SJVUAPCD for distribution. In 1994, projects approved by the Governing Board were awarded a total of $4.77 million. Alternative fuel vehicles received 36 percent of the funding, followed by transportation control measures with 35 percent; plans, studies and research with 18 percent; and public education with 12 percent.

Some of the projects funded in 1993-1994 included:

- The conversion of more than 200 vehicles throughout the district to operate on cleaner-burning alternative fuels
- A variety of studies on a number of topics including the adverse health effects of particulate matter such as vehicular dust emissions, and a light rail corridor
- Transportation control measures that implement bike plans, improve traffic flow and subsidize transit passes
- A district-wide auto buy-back program that will crush more than 700 pre-1975 heavily polluting vehicles
- Transit projects such as free downtown shuttle service

State & Federal Incentives for Alternative Fuel Vehicles

Alternative fuel vehicles currently cost more than regular gasoline because of the limited number of vehicles manufactured and because of the additional components that must be added (such as storage cylinders or extra fuel tanks). This will probably change as more AFVs are mass produced. To offset this differential or incremental cost of equipping vehicles to run on alternative fuels, various government agencies and a number of utility companies offer tax credits or deductions, and incentives to the purchasers.

Below are the incentives offered for 1995 model year alternative fuel vehicles.

California LEV Tax Credits (Current as of September 1994.)

For the tax years beginning on January, 1, 1991, and before January 1, 1998, state law (Senate Bill 2600 [Vuich, Chapter 1611, Statutes of 1990]; amended by Senate Bill 1071 [Kopp Chapter 768, Statutes of 1992] and by Senate Bill 146 [Lewis, Chapter 875, Statutes of 1993]) allows a state tax credit for the **incremental** cost of specified "low-emission" vehicles and "low-emission" retrofit devices.

The vehicle or device must be certified by the California Air Resources Board (contact the Energy Commission for latest list of certified vehicles), and all qualifying vehicles also must be registered in California. The incremental cost is determined by the California Energy Commission.

The state tax credit is for 55 percent of the **incremental** cost of a vehicle, or the cost (including installation) of a retrofit device, certified to meet the CARB low-emission requirements.

If there is no additional or incremental cost when compared to a gasoline-only vehicle, then the state tax credit does not apply. For example, if there is no cost charged by the manufacturer for the "low-emission" model then the credit does not apply.

The state tax credit is a **maximum** of $1,000 per automobile, motorcycle or two-person passenger vehicle; or $3,500 for a vehicle weighing more than 5,750 pounds.

If a federal tax credit is enacted for "low-emission" vehicles, the state credit is partially reduced by the amount of the federal credit. Funding for the state tax credits totals $750,000 for each year (1991 – 1998) and is available with prior certification by the California Energy Commission.

The taxpayer must submit to the California Energy Commission a Plan to Purchase Form and also a completed **Purchase/Installation** Form. If the Energy Commission verifies in **writing** that the vehicle is eligible for the credit, the purchaser would then be entitled to submit a Form 3554 with their State Income Tax.

California Sales Tax Exemption for LEVs (Current as of September 1994.)

Senate Bill 1006 (Leonard, Chapter 990, Statutes of 1989) allows for a state sales tax exemption on the incremental cost of a **certified** low-emission vehicle or on certified retrofit parts to convert a vehicle to be a low-emission vehicle. The exemption **ended** on **December 31, 1994.**

Federal Tax Credits and Deductions

The National Energy Policy Act (EPAct), signed by President Bush on October 24, 1992, contains major provisions for clean and alternative fuel vehicle federal tax credits and deductions. The fuels that are covered by EPAct are electricity, ethanol, methanol, natural gas and propane.

The law allows a tax **credit** of 10 percent of the cost of electric vehicles. The credit is based on the purchase price of the vehicle and may not exceed $4,000. The credit is available to vehicles placed into service after June 30, 1993, and prior to January 1, 2005. The federal tax credit is reduced by 1/4 in 2002, to a maximum of $3,000; 1/2 in 2003, to a maximum of $2,000; and 3/4 in 2004, to a maximum of $1,000. It is no longer available after 2004.

EPAct allows for a maximum of up to $2,000 federal tax **deduction** for clean-fuel vehicles that use clean fuels such as ethanol, methanol, natural gas or propane (liquefied petroleum gas or LPG). The federal tax deduction is based on the **incremental** cost of equipping the vehicle to use the clean fuel; the amount above the price of a regular gasoline-only vehicle. The federal deduction is available for vehicles placed into service after June 30, 1993, and before January 1, 2005.

A $5,000 federal tax deduction is available for alternatively-fueled trucks/vans weighing between 10,000 and 26,000 pounds. A $50,000 tax deduction is available for alternatively-fueled trucks/vans weighing more than 26,000 pounds, or for buses that can seat at least 20 passengers. The federal deduction is available for vehicles placed into service after June 30, 1993, and before January 1, 2005.

A federal tax deduction of up to $100,000 can be claimed for clean fuel refueling sites (including electricity). The federal tax deduction is available on sites placed into service after June 30, 1993, and prior to January 1, 2005.

Additional Incentives for AFVs

The California Energy Commission offered a $400 incentive toward the purchase price of the 1995 model year Ford Taurus Flexible Fuel Vehicle (FFV) that runs on methanol (M85). The incentive was paid directly to the auto company and was taken off the sticker price of the vehicle by the manufacturer. All 1,800 1995 Taurus FFVs being made by Ford, however, have already been purchased. The 1995 Dodge Intrepid FFV, like the Taurus FFV, is also certified by the California Air Resources Board but did not qualify for a state incentive. It is unknown if there will be future state incentives for methanol-powered vehicles in 1996 and beyond.

The Energy Commission also has limited funding for cost-sharing the incremental cost of original equipment manufacturer certified natural gas-powered pickup trucks and vans. Vehicles pending certification for 1995 include the Dodge B250 and B350 RAM Van, Wagon and RAM Pickup dedicated NGVs; Dodge Minivan NGV; Dodge Dakota Pickup NGV; and the Ford Crown Victoria NGV. Typically, these incentives are matched dollar-for-dollar by natural gas utility companies. A total of $1,000 is available for each NGV certified by CARB as **low emission (LEV)**, and **$1,500** is available for NGVs certified as **ultra-low emission (ULEV)**. The state incentive is available directly through California's three main natural gas utility companies (PG&E, SoCal Gas and SDG&E, and Chrysler Corporation for Chrysler NGVs) rather than as a rebate or reduction on sticker price to each purchaser.

Investor-owned natural gas and electric utility companies may be reducing their rebates or incentives in the future. Recent directions by the California Public Utilities Commission on how much can be spent by the utilities and the "down-sizing" of utility companies, mean that less rate-payer money may be used toward AFV incentives and rebate programs.

Incentives for credits for methanol-powered and other clean, alternative fuel vehicles are being offered by various air quality districts. As mentioned before, the Sacramento Metropolitan Air Quality Management District offers free methanol fuel (M85) for Fuel-Flexible Vehicle, and the South Coast Air Quality Management District and Bay Area Air Quality Management District offer vehicle ride-sharing credits for use of clean, alternative fuel vehicles.

For more information about the State Low-Emission Vehicle Tax Credits, please WRITE:

California Energy Commission
Low-Emission Vehicle Tax Credits
1516 Ninth Street, MS-41
Sacramento, CA 95814

For information on the federal tax credits or deductions, contact your local Internal Revenue Service Office. Please also contact your local air quality district and utility company for information about possible incentives they may be offering. Phone numbers for the major air quality districts are listed on the map on page 20.

Chapter 3
Electric Vehicles

In the words of a reporter from the *Chicago Tribune*, "The electric car is an idea whose time has come.....again."

Electric vehicles (EVs) have been around since the 1830s before they virtually disappeared in the 1910s.

At the turn of the last century, there were more electric vehicles on the road than there are today. And by the turn of the century, EVs are expected to make a comeback.

History of Electric Vehicles

The electric vehicle has a much longer history than most people realize. As pointed out in the book *The Green Car Guide*, the first known electric car was a small model built by Professor Stratingh in the Dutch town of Gröningen in 1835. But the first practical electric road vehicle was probably made either by Thomas Davenport in the United States or by Robert Davidson in Edinburgh in 1842.

These pioneers had to use non-rechargeable electric cells. An electric vehicle did not become a viable option until the Frenchmen Gaston Plante and Camille Faure respectively invented (1865) and improved (1881) the storage battery.

The performance of "La Jamais Contente" in 1899 brought the potential of the electric car to the attention of an enthralled world. This was the name for the unique streamlined racing car in which the Belgian Camille Jenatzy broke the world land speed record in France, the first car to go faster than 100 kph (62 mph).

C.D. Bohon, in the April 1994 issue of *Dealer Business* magazine, wrote an article entitled "The Once and Future Vehicle; History of the Electric Vehicle," that sums up the history of EVs, which we excerpt on the next page.

EVs Today

Electric vehicles have been in continual use since the 1910s in various applications: working in industrial plants, where internal combustion engine exhaust could endanger worker health; on golf courses, where quiet operation adds to the relaxing environment; on worksites to ferry employees between buildings; and on college campuses. But today these quiet and pollution-free vehicles are no longer overgrown golf carts. New advances in battery technology, system integration and aerodynamics, and commitments to research and development by major vehicle manufacturers are producing electric vehicles that play a practical role on city streets.

Several California cities use electricity to power buses, streetcars and mass transit, although some of these vehicles use an exterior power source like overhead wires (such as San Francisco's electric buses and Sacramento, San Diego and San José's light rail systems). EVs and electric buses that use internal power sources, however, are also on California's roads. As of May 1993, the California Department of Motor Vehicles had registered 2,877 electric-powered passenger vehicles.

EVs now being demonstrated have a range of around 100 miles, which according to the latest Caltrans trip data, is equal to three times the miles traveled daily by about 60,000 of the 150,000 commercial, light-duty fleet electric vehicle in Southern California.

According to the Northeast Sustainable Energy Association (NESEA), range records have increased from 35 miles to over 200 miles in six short years at the American Tour de Sol electric vehicle race. NESEA says that the range of EVs using lead acid batteries as their storage system, increased to 142 miles, as shown by a Fiat converted to electricity driven at the 1994 race.

Ranges of more than 150 miles have been achieved with nonspecialized EVs. A Solectria *Force*, a Geo Metro conversion, drove 214 miles recently using a nickel-metal-hydride battery built by Ovonic Battery of Troy, Michigan. Ovonic plans to have that battery on market by 1998.

According to reports in *Green Car Journal*, an electric car called the IZA produced by Tokyo Power Company, Meidensha and Tokyo R&D claimed a single charge distance of 343 miles in Japan. This was performed on a chassis dynamometer at a constant speed of 25 mph. In 1992, a Horlacher Sport EV

The Once and Future Vehicle; History of the Electric Vehicle

by C.D. Bohon

From: *Dealer Business Magazine*, April 1994.

In 1870, Englishman Sir David Salomons developed a light electric motor, which he used to propel a horseless carriage. The heavy weight of the batteries, however, limited its carrying capacity and range, making it noncompetitive with steam carriages. Salomons persisted, however, and in 1886 introduced a practical electric taxi. It used a battery with 28 cells and a small electric motor. It had a range of about 40 miles cruising at 8 mph.

The heyday of the electric was from about 1890 to 1910. Lead-acid and nickel-iron batteries were developed that made the electric vehicle a viable urban transporter.

Walter Bersey, a Brighton native, became a leader in electric vehicle development. In 1896, he drove one of his electrics from Brighton to London. The next year, the London Electric Cab Company inaugurated regular service with Bersey electric cars. These used 40-cell batteries powering a 3-horsepower motor. The vehicle could travel 50 miles between recharges at speeds up to 10 mph.

That same year, the electric vehicle was introduced in America when the Hartford, Conn.-based Pope Manufacturing Co. began building electric cars at the rate of 250 a year — quite a feat in the years before mass production was developed.

Shortly, two other American companies, the Columbia Co. and Electric Vehicle Co., were also manufacturing electrics. In these years, the prospects for electric vehicles were as hot as those for interactive media are today. Through a series of financial buy-outs and mergers, Electric Vehicle gained major control of the electric vehicle business. In 1899 it was worth $200 million, a stupendous sum in those days, and was manufacturing thousands of electric vehicles annually.

Electric Vehicle, now long forgotten, was by far the largest vehicle manufacturer of its time. By 1904 it was building one-third of all the taxicabs used in New York, Chicago and Boston. It also produced electric trucks and buses. It set up electric car rental agencies in New York and Chicago.

Battery storage capacity still hampered performance, and the company urged the development of chains of battery charging stations to solve the problem. To avoid multi-hour waits while batteries were recharged, the plan was to have a driver pull into an electric service station, where the depleted batteries would be replaced by freshly charged ones.

In 1900, some 57 companies were manufacturing self-propelled vehicles in the United States. Half were electric, one-fourth were steam and one-fourth were gasoline.

In those days, the gasoline engine seemed to have a limited future. It was noisy, smelly, smoky, vibrated terribly, and ran on an explosive fuel that was expensive and in short supply.

Electric cars were viewed as "the most nearly perfect automobile" in the words of one commentator. Everyone recognized they were severely hampered by the limited storage capacity and heaviness of available batteries. But it was assumed technological development would soon solve those problems.

Steam-powered vehicles were fettered by the need for frequent stops for water, and they burned fuel inefficiently, but it was assumed the wealth of technical know-how on steam engines throughout society (they powered not only trains and ships, but factories, as well) would make them potential rivals with electrics.

Gasoline engines were out of the running, almost everyone agreed. But then, suddenly, gasoline engines overwhelmed both steam and electric. In a handful of years, electrics moved from being the wave of the future to being as antique as high-button shoes. The roar of the Roaring Twenties was the sound of millions of gasoline-engined cars.

Part of what happened was progress outside the auto industry. Chemists developed inexpensive cracking techniques that enabled cheap volume production of gasoline from oil. Prior to this, gasoline was sold by the pint at drug stores. Its primary use had been as a cleaning solvent.

Part of what happened was also coincidence. Ransom Olds, one of the great automotive pioneers, built his first car in 1891. It was a steamer. Five years later, he built a gasoline-engined car. Olds built the first factory in the United States intended solely for the production of automobiles to manufacture a two-cylinder gasoline-engined car.

This vehicle sold poorly, however, and Olds had turned his attention to developing an automobile powered by the more popular electric motor when a fire razed the factory, including the prototype electric cars. Only one prototype was saved, a lightweight, single-cylinder gasoline engine-

powered runabout with a curved dashboard.

Financially devastated by the fire, Olds was forced to abandon his plans for electrics and build the curved dash model. It proved popular, coming on the market just as cheap gasoline was becoming available. The Oldsmobile, as it was called, became the best-selling car in the country. In 1908, when Buick and Oldsmobile were joined together to form General Motors, Olds' plans to build electrics were long forgotten.

Henry Ford also toyed with the idea of building an electric car. But he hated heavy vehicles with a passion, and the lead-acid batteries of electrics made them ponderous. He despised steamers as inefficient. So when he began producing cars in 1904, they were powered by gasoline engines.

Gasoline engine-powered cars soon proved themselves vastly superior to electrics in one crucial area — range. You couldn't drive an electric outside the city because your battery would run down and it would take hours and hours to recharge it. But gasoline cars could travel two and three times farther than electrics before they needed more gas. And if you worried about supplies, you could carry a spare can of gas with you.

Gasoline-engined cars opened up the country. Even farmers bought them. Electrics faded fast.

The Electric Vehicle Co., reorganized as Columbia Motor Co., declared bankruptcy in 1910. In 1911, Studebaker, the second biggest manufacturer of electric cars, dropped its electrics to concentrate on gasoline-engined vehicles.

While "civilians" were turning to gasoline cars, urban delivery companies stuck with electric trucks. Until after World War I, such companies as American Express and Gimbel's used more electrics than gasoline-powered trucks. Range was not a problem and their quietness and extreme reliability compared to cranky gasoline engines made them ideal for that type of work.

The invention of the self-starter for the gasoline engine doomed the electric. Until them, the brute strength needed to hand crank a gasoline motor to life caused many to shy away from them, preferring the docile electric.

By 1920, the electric vehicle was nothing more than a quaint, old-timey vehicle. It's doubtful if anyone ever thought electrics would be revived.

But urban pollution caused by fossil fuel-powered motor vehicles has become a stubborn problem with no practical and inexpensive solution. Activists call for zero emission vehicles (ZEVs), and that means electrics. ★

EVs Today (continued)

powered by sodium-sulfur batteries ran 340 miles nonstop at an average speed of 74 mph in Switzerland.

Acceleration is improving as the technology matures and as systems are more skillfully integrated and managed. Freeway driving speeds are usual for most full-sized EVs. *The Los Angeles Times* reported that "AC Propulsion, a small California company run by engineer Alan Coconni, showed off a 200-horsepower EV at the 12th International Electric Vehicle Symposium in Anaheim (in December 1994). The car can do zero-to-60 in 6.2 seconds"...acceleration many gasoline-powered vehicle owners would envy. And the world record top speed for an electric-powered vehicle is 183.075 mph done in the summer of 1994 by a specially modified GM Impact, the prototype EV first unveiled by General Motors in 1990.

Electric vehicles may be the choice for California urban commuters (for many as a second car) because of strict air quality regulations. California Air Resources Board regulations require that two percent of all vehicles offered for sale by major automakers (Chrysler, Ford, General Motors, Honda, Mazda, Nissan and Toyota) will have to be zero (tailpipe) emission vehicles starting in model year 1998. That number rises to five percent in 2001 and ten percent in 2003; or approximately 200,000 vehicles per year in 2003.

A recent poll of Californians done for the prestigious *Automobile Week* magazine says that 63 percent of Californians would buy an electric vehicle. Other polls in the past say that we are likely to buy EVs...if the price is right.

The South Coast Air Quality Management District expects 19 percent of all light-duty passenger vehicles and seven percent of the light-duty trucks in that district will be ZEVs by 2010 (a total of more than 2.5 million vehicles in Southern California).

The Energy Commission calculates fewer EVs statewide, saying in its *CalFuels Plan* that a total of 1.3 million electric vehicles will be in all of California by 2010. By that year, electric vehicles will consume an estimated 7,483 gigawatt/hours of electricity – about 3.2 percent of the total electricity consumed in California (in 1993).

Most EVs will recharge during off-peak hours (such as overnight). Off-peak recharging makes use of electric power plant capacity that normally would sit idle. Few people are using electricity overnight, so the plants are either shut down or scaled back to

low output levels. Using these idle power plants would make the electricity system more efficient overall, thus helping to stabilize electricity rates.

According the Commission's *CalFuels Plan*, investor-owned and municipal utilities estimate that they can meet the electricity demand for EVs with little or no additions to their generation or transmission systems for the next 15 years. These estimates assume that most of the recharging will occur off-peak. Assuming EV demand is managed, only about 4.5 percent of EV charging will occur on-peak (during the afternoon and early evening).

Southern California Edison estimates that it will need to add only 200 megawatts of capacity by 2008 to accommodate EVs. Such capacity can be made up by saving energy elsewhere (demand-side management) rather than having to build new power plants. Other utilities found no need to add generation capacity or transmission lines to meet EV energy demand in the next 15 years.

EV Emissions

There are zero tailpipe emissions associated with electric vehicles, and even when California and out of state power plants are figured into the air pollution, ZEVs are still 97 to 98 percent cleaner that gasoline-powered vehicles. In other states that rely on coal and petroleum for their electricity, the vehicles may not be as clean as in California.

California's electricity production is diverse. More than one-quarter of our electricity comes from renewable resources: hydroelectric, wind, solar, geothermal and biomass. Most of our electricity comes from clean-burning natural gas.

Like our transportation sector is today, California's electricity production was heavily dependent on petroleum. Twenty years ago, more than 50 percent of our electricity came from burning oil in power plants. California recognized that this put the state at risk economically whenever there were fluctuations in the price and supply of oil. The state recognized that oil-fired power plants were heavy air polluters. So, the electric utility industry converted to other cleaner fuels. Today, less than one percent of our electricity comes from burning petroleum. (Note: The numbers in the chart above for natural gas include plants that can burn both petroleum and natural gas. Most use natural gas, however, because of air quality concerns.)

The state is now applying that policy of diversification to the transportation sector with its move toward clean, alternative fuels.

EVs in Fleets

One of the key concerns when fleets consider buying EVs is certification. The California Air Resources Board certifies which vehicles will meet its Low Emission Vehicle requirements. Currently certified vehicles are listed below. Many fleets have begun using smaller utility EVs, such as meter reader and service vehicles. The lifespan of an EV is expected to be longer than a conventional vehicle because there are fewer parts to break and lower maintenance costs. This could help offset the higher initial costs of an EV.

Questions & Answers About Electric Vehicles

When will EVs be in California? Electric vehicles are already in California. According to the Department of Motors Vehicles, there were nearly 3,000 vehicles registered as EVs in 1993.

Are EVs being sold? EVs are being sold by a number of up-fitters, conversion companies or specialty car companies that sell converted gasoline vehicles. Other companies/dealers sell smaller neighborhood electric vehicles (NEVs). NEVs are usually small one or two seaters with top speeds of about 35 to 40 mph.

What about the major auto companies? Chrysler Corporation is currently selling a limited number of its Dodge TEVans (an EV minivan) to utility companies at about $100,000 each for demonstration purposes. Ford, GM and Honda are all demonstrating prototype EVs, but do not currently offer any for sale. Beginning in 1998, auto companies that annually sell more than 35,000 vehicles in California will have to offer at least two percent of all their vehicles as Zero Emission Vehicles – or electrics. That increases to five percent in 2001 and ten percent in 2003. In 1998, EVs are expected to sell in the $15,000 to $30,000 range.

Does an EV have an engine? No. EVs do not have an internal combustion engine. EVs are powered by one or more electric motors that are fueled by electricity, including batteries, fuel cells (see Chapter 9), or by sunlight powering photovoltaic (PV) or solar cells.

How are EVs different from regular internal combustion vehicles? According to CALSTART, the advanced transportation consortium in California, 70 percent of an electric vehicle's component parts may

California's Electricity Resources by Source for 1994
(Dependable Capacity in Megawatts)

Type of Power Plant	*MW*	*Percentage*
Biomass	1,031	1.8
Coal	4,232	7.4
Cogeneration	5,640	9.9
Geothermal	1,901	3.3
Hydro/Pumped Storage	10,125	17.7
Natural Gas/Petroleum	23,106	40.2
Nuclear	5,327	9.3
Solar	365	0.6
Wind	333	0.6
Out-of State Imports	5,082	8.9
Total	57,142	

Source: California Energy Commission staff.

be different than a conventional vehicle. An EV has no internal combustion engine, no liquid fuel tank, no fuel lines, no carburetor, usually no radiator, and many other components. EVs have, however, some high-tech equipment that is often associated with the aerospace and defense industry. So, many jobs that were lost in California because of down-sizing of national defense-oriented companies could be recouped in production of EV components. CALSTART estimates that producing EV components in California could create as many as 40,000 jobs.

What type of batteries are being used in EVs? In advanced conversions and prototypes like the General Motors *Impact* , batteries are likely advanced, sealed lead-acid. When EVs are in full-scale production by the end of the 1990s, we can expect to see more advanced batteries. These include: advanced, sealed lead-acid; nickel-metal-hydride; nickel-cadmium; sodium-sulfur; zinc-air; lithium-metal-disulfide; sodium-nickel-chloride; lithium-ion; ultra-capacitors and others. The U.S. Advanced Battery Consortium, a coalition of the federal government and the big three American auto companies, has been created to do advanced research on battery technologies.

How far can an EV go? As in a conventional vehicle, range depends on a number of factors. In an EV, range depends on the type of batteries, the number of batteries, the driving conditions, whether driving is in the city or on the highway, the driver, and the vehicle itself. Many EVs today have a range of between 60 to 100 miles. According to the California Air Resources Board, when EVs hit the market in 1998, they will probably have a range of about 200 miles before needing to be recharged.

How do you recharge an EV? An EV is usually plugged into some type of electrical connector at the owner's home. This can be a regular 120 volt wall outlet or a 220 volt / 40 amp line (like the type used for electric stoves and clothes dryers). Eventually, fast-charging public fueling stations will be available. The vehicle draws current from the electrical source and stores that energy in the battery system. There are currently two types of recharging "plugs:" an inductive charging connector, made by the General Motors subsidiary Hughes Power Systems, and a conductive charging connector, supported by Ford and Chrysler. Decisions will have to be made as to which system will be used by EVs. Some liken the debate between inductive and conductive to the VHS versus Beta fight for video cassette recorders.

How long does it take to charge an EV? Most EVs will normally be recharged in three to eight hours, depending on the charging voltage (110 or 240 volts) and how "drained" the batteries are. Quick-charging technologies would provide 60 to 80 percent of the charge to high-charge-density batteries (20 to 60

kilowarr/hours) in five ro 15 minures. Quick-charging rechnology prorotypes have been developed bur will require significanrly more developmenr and resring before commercialization.

How much do EVs cost? Limired production EVs made by specialty companies roday are priced in rhe $20,000 ro $40,000 range. One company is currently offering an two-searer fiberglass EV sports car with a range of 60 to 80 miles for about $16,000. When EVs are in full-producrion by the turn of the century, the price should be in the $15,000 to $30,000 range, much like the spread in car prices today.

Can a gasoline vehicle be converted to an EV? Yes. Many EV pioneers, such as members of the Electric Automobile Association, have been converting gasoline vehicles or building "kit" EV cars for many years. EV conversion kirs are sold for some popular cars such as VW Rabbits, Honda Civics and other lighter cars. A number of companies sell these conversion kirs and step-by-step instructions for building an EV. Some of these kits are certified by the California Air Resources Board. Remember, however, that EVs store a tremendous amount of electricity in their batteries. One could be seriously injured through electrical shocks if precautions are not taken. One should read up about safety around electricity before beginning such a project. Also, a converted car does not necessarily meet federal crash safety tests, and the buyer should carefully consider this prior to purchase.

How much does a conversion/kit cost? Kits can range from about $4,000 to $5,000 on up (to vehicles that have already been converted for tens-of-thousands of dollars), not including the cost of the gasoline vehicle's shell. Taking out the engine and drive train and selling that for parts may recoup some of the cost of the conversion kit.

What is the cost per mile of running an electric vehicle? It depends on the initial cost of the fuel. The price can run from five cents a kilowatr/hour (kWh) of electricity for off-peak charging (overnight) to up to 35 cents per kWh for charging during peaks hours at an "opportunity charger." This equates to 1.5¢ to 10.4¢ per mile. Gasoline, by comparison is about 4.0 cents per mile ar $1.19 per gallon and a vehicle getting 29.7 mpg. Most EV customers, however, should be able to get the lower overnight charging rates...so their cost of operating the vehicle will be very low. The maintenance costs for an EV should also be significantly lower than their conventional gasoline counterparts.

What is opportunity charging? This is when you can plug an EV inro a merered plug-in connecror, such as ar a srore or parking garage and charge your vehicle during the daytime. You could be billed for rhe convenience of "charging up" your battery, or "free charging" could be a marketing incentive for shopping malls or downtown areas. If you are ro pay, you could use a coin- or credir card-operated meter, or you could pay an attendant. Some opportunity charging starions have already been set up in municipal garages, but vehicles are not being charged for the small amounts of electricity they are using.

Do you have to replace the batteries? How often? Batteries will have to be replaced after a period of time. Constant cycling of the batteries, or just their calendar life, can deplete its ability to store electricity. How often replacement will occur depends on the battery type, the climate and how much the vehicle is driven. The California Air Resources Board estimates an advanced battery pack's useful life ar about five to ren years in 1998.

How much will the battery pack replacement cost? Won't batteries add to landfills? Again, it depends on the battery type, etc. The price of battery packs varies by type. Most lead-acid batteries are currently recycled. We recycle more than 90 percent of lead-acid batteries in the country. The acid is drained from the battery, cleaned and recycled as electrolyte in new batteries, the lead is taken out and reused, even the plastic case can be recycled. When EVs become more commonplace, the amount of batteries needing to be recycled will increase – creating more jobs and economic opportunities. Each proposal for government funding for advanced batteries must include a recycling plan.

What other maintenance does an EV require? Newer, sealed batteries do not require watering like older-style lead-acid batteries, but because an EV has fewer moving parts, you will not have to do oil changes, transmission fluid changes, etc. like you would with a conventional vehicle. Other vehicle maintenance, such as wipers and safety equipment will have to be checked no matter what fuel is powering the vehicle.

What about EV safety? Concerns do exist over safety with EVs. Batteries will usually be completely sealed, but there is a chance of leakage of acid (in lead-acid batteries) in case of a collision. Some lead-acid batteries use a paste or gel rather than a liquid acid, further making them less likely to spill. There are also

concerns over the possible presence of flammable, toxic or corrosive materials in EV batteries – safety training will have to address this. Problems of electrical dangers in charging, and training of personnel in commercial repair garages and service centers will also have to be addressed. Many of these issues are being discussed by industry working groups of the electric utilities, private companies, government agencies and research organizations to solve the concerns before EVs come to market.

Electric Vehicles Currently On the Road

EVs produced by a number of specialty car companies (based on kits, conversion of gasoline vehicles or limited production models) are available to the general public and fleets. These vehicles typically use lead-acid batteries, have limited to medium ranges and do not as yet come with major automakers' warranties. They can cost around $25,000 to $40,000. Two of the larger firms that build conversions and specialty EVs are Solectria in Waltham, Massachusetts, and U.S. Electricar in Santa Rosa, California. Renaissance Cars Inc. of Florida recently announced that it will soon sell a two-seater fiberglass-body sports car for about $16,000. And Solectria announced at the 12th Annual Electric Vehicle Symposium in December 1994, that it will be building a brand new, four passenger EV called the *Sunrise* and selling it for about $20,000.

The "Big Three" American and foreign car companies are all working on EVs. General Motors electric passenger car is the *Impact*, which can achieve a speed of 75 miles per hour, accelerate from 0-60 in 8 seconds, and travel 70 to 90 miles before needing a recharge. In early 1991, GM announced that it will produce the electric vehicle in Michigan at the former assembly plant for the Buick *Reatta* but may use a *Corvette* assembly plant. GM originally planned limited production of an *Impact*-like EV by 1995 but delayed introducing the vehicle for sale to the public until the late 1990s. GM produced approximately 50 pre-production *Impacts* to loan out to more than 1,000 electric utility customers in 12 cities around the country for two to four weeks in a special test program. The *Impact* will be test-driven by electric customers in Los Angeles, Sacramento, San Diego and San Francisco.

Ford Motor Company has produced the *Ecostar*, a European *Escort* Minivan retrofitted with an electric power train and using sodium-sulfur batteries for testing purposes. The *Ecostars* have currently logged more than 250,000 miles in a test of more than 100 vehicles in delivery fleets around the country. Ford has not said whether or not it will offer an EV in 1998, or what model it will offer.

Ford recently entered into an agreement with U.S. Electricar to discuss an arrangement to supply Electricar with "gliders," a vehicle chassis without the power train. This can cut the cost of an EV made on a converted gasoline vehicle by up to 30 percent. Ford may enter into an agreement to market the smaller company's EVs and put a Ford logo on the vehicle and use those to meet its CARB requirement.

Chrysler is currently selling its *TEVan*, which uses nickel-cadmium batteries. The vehicle can be purchased today for about $100,000. Chrysler currently only produces a limited number of these EV-powered minivans each year, which are mostly sold to government and research agencies and to electric utility fleets.

Foreign manufacturers are also working on EVs for the 1998 California market. Nearly all of them, including some not impacted by the CARB standards, have premiered electric vehicles at auto shows in California, but most have been secretive about their plans to meet the Zero Emission Vehicle standards.

According to recent media reports: Toyota will probably sell its *EV-50*, an electric version of a popular small sport-utility vehicle that is sold in Japan. The car has a top speed of 75 mph and a range of 70 miles. A number of *EV-50s* are expected to be in placed in demonstration fleets next year.

Honda has been running a demonstration program with eight *CUV-4s*, a Honda *Civic* hatchback EV. They are in fleet use with Pacific Gas and Electric Company and Southern California Edison. Honda say it will probably redesign a body for its EVs.

Peugeot may introduce an EV in the U.S. Their EV is currently under going testing in France. Its estimated price tag is $12,000.

Other European car companies are also working on EVs. BMW and Mercedes have both shown prototype EVs at California auto shows. Volvo officials, however, say they will not sell an EV. The company is working on a special hybrid that uses a gas turbine generator to produce electricity to power electric motors and charge batteries. The Volvo Environmental Concept Car (ECC) was unveiled at the Greater Los Angeles Auto Show.

One the next page is a list of 1994/1995 model year EVs that have been certified (as of November 11, 1994) by the California Air Resources Board. Also included is the number of charging locations in various utilities' service territory, as of December 1994.

Current CARB-Certified Electric Vehicles
(As on November 14, 1994)

- Advanced Electric Car - 3 models (conversions)
- Blue Bird Body Company - TCEV 3204 School Bus
- Chrysler TEVan - Dodge Caravan/Plymouth Voyager
- City Com - City-EL, (Neighborhood EV)
- Cushman - "ZEV" meter reader utility vehicle
- Drive Electric - 9 models (conversions)
- Ford Ecostar - limited production
- GM Impact - limited production
- Green Motorworks - Kewet El-Jet (Neighborhood EV)
- Renaissance Cars, Inc. - Tropica
- Solectria - "Force" EV - 4 models (conversions)
- Specialty Vehicles - 4 models of shuttle buses
- U.S. Electricar - 11 models (conversions & purpose built)
- Westward - GO-4E (three-wheel "police" electric motorcycle

EV Charging Locations in California by Utility
(Includes off-board chargers and plug configurations for on-board chargers – as of 12/94)

Serving Utility	*Charging Stations*	*Total Locations*	*Public Stations*	*Public Location*	*Private Stations*	*Private Locations*
Burbank	2	1	2	1	0	0
Glendale	4	1	0	0	4	1
LADWP	118	32	36	8	82	24
PG&E	14	5	3	2	11	3
Riverside	4	1	4	1	0	0
SCE	59	33	25	2	34	31
SDG&E	1	1	0	0	1	1
SMUD	158	39	96	20	62	19
Total	**360**	**113**	**166**	**34**	**194**	**79**

EV Contacts

Automakers, Equipment & Conversion Companies

Alan Cocconi
AC Propulsion
462 Barrega Ct.
San Dimas, CA 91773
(conversion kits)

Ed Atelia, Chairman
APS Systems
3535 West Fifth Street
Oxnard, CA 93030
805-984-0300
(EV shuttles and buses)

Beyond Oil
P.O. Box 99
Mill Valley, CA 94942
(conversion kits)

Drive Electric of Sacramento
1206 C Street
Sacramento, CA 95814
916-442-5100
(conversion kits and vehicles)

Dean Falk
Electrical Rebuilders Inc.
N5 W22966
Bluemound Road, East
Waukesha, WI 53186
414-548-0777
(conversion kits)

Electro Automotive
P.O. Box 1113
Felton, CA 95018-1113
(conversion kits)

John Wallace
Director, Electric Vehicle
Planning & Program Office
Ford Motor Company
23400 Michigan Avenue,
Suite 230
Dearborn, MI 48124
313-390-5589

Raymond Buttacavoli
Industry-Government Relations
General Motors Corporation
515 Marin Street, Suite 216
Thousand Oaks, CA 91360
805-373-8495

Cheryl Oloff
Electric Vehicle Program
Public Relations
General Motors Corporation
Mail Code 23, 1450 Stephenson Hwy.
Troy, MI 48007
810-528-6234

Beth Yaung
GM Electric Vehicle Program
1383 Oakridge Court
Thousand Oaks, CA 91362
805-374-8719

Bill Meurer
President
Green Motorwarks
5228 Vineland Avenue
North Hollywood, CA 91601
818-766-3800
(EVs and conversion kits)

Fred Silver
Marketing Manager
Hughes Power Control Systems
Loc. TO, Bldg. 237, MS 1450
3050 West Lomita Blvd.
Torrance, CA 90509
310-517-5717

Inductran
1326 Ninth Street
Berkeley, CA 94710
415-526-5590
(inductive charging equipment)

Kaylar Energy Products
20000 Big Basin Way
Boulder Creek, CA 95006
(conversion kits)

KTA Services
12531 Breezy Way
Orange, CA 92669
(conversion kits)

MendoMative Electric Vehicles
30151 Navarro Ridge Rd.
Albion, CA 95410
(conversion kits)

Jamie Lowe
Marketing Director
Nordskog Electric Vehicles
1981 West Redlands Blvd.
Redlands, CA 92373
909-793-2891

RR Electric Car
2430 Orange St.
Martinez, CA 94553
(conversion kits)

San Diego Electric Auto
9011 Las Coches Rd.
Lakeside, CA 92040
(conversion kits)

Douglas Cobb
President
Solar Car Corporation
1300 Lake Washington Road
Melbourne, FL 32935
407-254-2997
(conversion kits)

Solarmax Corporation
2929 Tallevast Rd.
Sarasota, FL 34243
(conversion kits)

Tisha Kirk
Public Relations
Saletria
27 Jason Street
Arlington, MA 02174
508-658-2231

James Warden
CEO / Director of R&D
Saletria
27 Jason Street
Arlington, MA 02174
508-658-2231

Don Duffy
President
Specialty Vehicle Manufacturing Corp.
9250 Washburn
Downey, CA 90241
310-904-3434

3E Vehicles
P.O. Box 19409
San Diego, CA 92159
(conversion kits)

Rick Godber
President
Trojan Battery Company
12380 Clark Street
Santa Fe Springs, CA 90670

Ted Morgan
President and CEO
U.S. Electricar
P.O. Box 6645
Santa Rosa, CA 95406
707-525-3227

Ray Geddes
Chairman
Unique Mobility Inc.
3700 South Jason Street
Englewood, CO 80110
303-761-2137

Fuel Providers & Utility Research Organizations

Matt McCabe
Electric Vehicle Program
Alameda Bureau of Electricity
2000 Grand Street
P.O. Drawer H
Alameda, CA 94501
510-748-3901

Robert A. Bell
Vice President,
Research & Development
Consolidated Edison Co. of New York
4 Irving Place, Room 1422
New York, NY 10003
212-460-3882

Donald H. Denton, Jr.
Senior Vice President
Planning & Operating
Duke Power Company
PB04M, 422 South Church Street
Charlotte, NC 28242
704-373-4736

Thomas Morron
Vice President
Customer Services & Marketing
Edison Electric Institute
701 Pennsylvania Ave., N.W.
Washington, DC 20004
202-508-5650

Barbara Kline
Public Relations Manager
Electric Power Research Institute
P.O. Box 10412
3412 Hillview Avenue
Palo Alto, CA 94303
415-855-2000

Arnold Frickett
VP-Consumer Systems Division
Electric Power Research Institute
P. O. Box 10412
3412 Hillview Avenue
Palo Alto, CA 94303

Carol Precobb
Electric Power Research Institute
Electric Transportation Info Center
501 14th Street, Suite 210
Oakland, CA 94612
800-848-ETIC

Mindy Berman
Public Relations Office
Los Angeles Dept. of Water & Power
P.O. Box 111
Los Angeles, CA 90051
213-367-1344

Tom Doughty
Director Electric Transportation
Los Angeles Dept. of Water and Power
111 North Hope Street, Room 1106
Los Angeles, CA 90012
213-481-5698

Cheryl Popp
Corporate Communications
Pacific Gas and Electric Company
Mail Code B29E
P.O. Box 770000
San Francisco, CA 94177
415-972-5206

Bill Sessa
Bureau Chief, Corporate
Communications
Pacific Gas and Electric Company
925 L Street, Suite 890
Sacramento, CA 95814
916-446-6616

Mike Wirsch
Manager, Electric Transportation
Sacramento Municipal Utility District
Electric Transportation Dept., MS-30A
6201 S Street, Box 15830
Sacramento, CA 95852
916-732-6754

Dace Udris
Media & Education Services Dept.
Sacramento Municipal Utility District
6201 S Street, P.O. Box 15830
Sacramento, CA 95813
916-732-5201

Stephanie Donovan
Public Relations
San Diego Gas & Electric
8306 Century Park Court
San Diego, CA 92123
619-696-4285

Howard Levine
Manager, Alternative Vehicles
San Diego Gas & Electric
8306 Century Park Court
San Diego, CA 92123
619-654-1111

Diane O. Wittenberg
Manager of Electric Transportation
Southern California Edison Company
2244 Walnut Grove Avenue
Rosemead, CA 91770

Melanie Savage
Corporate Communications
Representative
Electric Transportation Department
Southern California Edison Company
GO1 - Room 418, 2244 Walnut
Grove Avenue
Rosemead, CA 91770
818-302-7948

Government

California Energy Commission
Transportation Technology & Fuels Office
1516 Ninth Street, MS-41
Sacramento, CA 95814
916-654-4634

Ruth Anne Keister
Manager
Clean Cities Hotline
P.O. Box 12316
Arlington, VA 22209
1-800-C-CITIES

Dan Sperling
Director
Institute of Transportation Studies
University of California, Davis
Davis, CA 95616
916-752-7434

Jeff Kahn
U.S. Advanced Battery Consortium
c/o Lawrence Berkeley Laboratory
Berkeley, CA
510-486-4019

Linda Bluestein
Contract Manager
National Alternative Fuels Hotline
P.O. Box 12316
Arlington, VA 22209
800-423-1DOE (1363)

National Appropriate Technology
Assistance Service (NATAS)
P.O. Box 2525
Butte, MT 59702
800-428-2525

Coral Hammel
(Dedicated EVs)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401
303-231-7836

Terry Penney
(Hybrid EVs)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401
303-231-1756

Greg Dolan
New York State Energy Research &
Development Authority
Two Rockefeller Plaza
Albany, NY 12223
508-465-6251 ext 226

Steven Scharf
U.S. Department of Defense
Advanced Research Projects Agency
3701 N. Fairfax Dr.
Arlington, VA 22203-1714
703-351-8471

Ann Hegneauer
Editor, OTT Times
Office of Transportation Technologies
U.S. Department of Energy
Room 6B094, EE-30,
Forrestal Building
1000 Independence Ave., S.W.
Washington, DC 20585
202-586-8014

Kenneth Barber
Electric & Hybrid Propulsion
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585
202-586-2198

Lionel Vera
S.F. Regional Support Office
U.S. Department of Energy
1301 Clay Street, Room 1060, North
Oakland, CA 94612
510-637-1945

Larry Hart
Office of the Press Secretary
U.S. Department of Energy
Forrestal Building
1000 Independence Ave., S.W.
Washington, DC 20585
202-586-5806

Richard J. King
Office of Solar Energy Conversion
U.S. Department of Energy
Photovoltaic Division
CE-131 5H-072/FOR
1000 Independence Ave., SW
Washington, DC 20585
202-586-1693
(manages solar race car competition between colleges/universities)

Carl Helman
National Vehicle &
Fuel Emissions Laboratory
U.S. Environmentol Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4246

Tad Wysor
Clean Fuel Fleets Program
U.S. Environmentol Protection Agency
2656 Plymouth Road
Ann Arbor, MI 48105
313-668-4332

David Gushee
Senior Specialist, Environmental Policy
U.S. Library of Congress
Congressional Research Service
Washington, DC 20540
202-707-7228

Companies, Organizations & Individuals

Howard Wilson
Electric Vehicle Consultant
2050 Mandeville Canyon Road
Los Angeles, CA 90049
213-476-4647

Dr. Paul MacCready
Chairman
AeroVironment Inc.
222 East Huntington Drive
Monrovia, CA 91016
818-357-9983

E. Eugene Ecklund
Executive Director
Alternative Transportation
Fuels Foundation
HCR-72, Box 547-8 LOW
Locust Grove, VA 22508
703-972-0484

Peter Baljet
Chairman
American Lung Association
National Air Conservation Commission
9350 South Dixie Highway, Ste. 1540
Miami, FL 33153
305-670-6774

Josh Newman
Vice President
Amerigon
425 E. Huntington Drive
Monrovia, CA 91016
818-305-1100

David E. Bruderly
Bruderly Engineering Associates
1826 N.W. 57th Terrace
Gainesville, FL 32065
904-377-0932

Cecile Martin
Deputy Executive Director - CalETC
Calif. Electric Transportation Coalition
925 L Street, Suite 1490
Sacramento, CA 95814
916-552-7077
Internet: CalETC@ix.netcom.com

Bill Van Amburg
Communications Director
CALSTART
3601 Empire Avenue
Burbank, CA 91505
818-565-5606

Patrick Brown
Center for Alternative Fuels
B.C. Research
Rural Route 1
Pender Island, B.C.
CANADA V0N 2M0
604-629-3073

Wayne Parker
General Manager
Clean Air Vehicle Association
14 Piedmont Center, Suite 1205
Atlanta, GA 30305
404-237-1980

Coalition For Clean Air
122 Lincoln Blvd
Venice, CA 90291
213-450-5192

Denver Electric Vehicle Council
2940 - 13th Street
Boulder, CO 80304

Spencer Adler
EcoTech Environmental Technologies
National Capitol P.O.
Mail Drop Box A
Washington, DC 20013
202-547-7313

Paul Brown
Executive Director
Electric Association of America
701 Pennsylvania Ave., NW
Washington, DC 20004
202-508-5414

Paul Brasch
Electric Auto Association
1968 Elden Drive
San Jose, CA 95124

Hal & June Munro
Electric Auto Association
2710 St. Gile Lane
Mountain View, CA 94040
510-685-7580 or 800-537-2882

Dr. John Newell
Electric Auto Association
1249 Lane Street
Belmont, CA 94002
415-591-6698

Paul Heaney
Electric Grand Prix
6 Gateway Circle
Rochester, NY 14624

Electric Transit Vehicle Institute
1617 Wilcox Boulevard
Chattanooga, TN 37406
615-629-1411

Electric Transportation Coalition
1050 Thomas Jefferson N.W.,
6th Floor
Washington, DC 20007
202-298-1935

Gail Hendrickson
Electric Transportation Coalition
701 Pennsylvania Ave., N.W.,
4th Floor
Washington, DC 20004
202-508-5995

Athena Miller
Electric Vehicle Association of the Americas
601 California St., Suite 502
San Francisco, CA 94108
415-249-2690

Electric Vehicle Council of Ottowa (EVCO)
8ox 4044, Station E
Ottowa, Ontario
CANADA K1S 581

David Goldstein
President
Electric Vehicle Industry Association
9140 Centerway Drive
Gaithersburg, MD 20879
301-231-3990

Margaret Morgan-Hubbard
Executive Director
Environmental Action
Environmental Action Foundation
6930 Carroll Avenue, Suite 600
Takoma Park, MD 20912
301-891-1100

Lawrence Dussault
Great Lakes Electric Auto Association
568 Braxton Place East
Westerville, OH 43081
614-899-6263 or 800-GLEAN-44

David P. Lefever
Executive Director
National Assn. of Fleet Administrators
120 Wood Avenue South, Suite 615
Islelin, NJ 08830
908-494-8100

Cathy Bergman
National EMF Alliance
410 West 53rd Street, Suite 402
New York, NY 10019
212-554-4073

Dr. John Reuyl
NEVCOR (Hybrid EVs)
P.O. Box 8683
Stonford, CA 94309

Lisa Petraglia
Northeast Sustainable Energy Association
23 Ames Street
Greenfield, MA 01301
413-774-6051

L. Donald Shields
Coordinator
Project California
Calif. Council on Science & Technology
100 Academy Drive
Irvine, CA 92715
714-854-4150

Amory B. Lovins
Director of Research
Rocky Mountain Institute
1739 Snowmass Creek Road
Snowmass, CO 81654
303-927-3851

Ernie Holden
Solar & Electric Racing Association
11811 North Tatum 8lvd., Suite 3031
Phoenix, AZ 85028
602-953-6672

Steve McCrea
South Florida Electric Auto Association
1402 E. Las Olas Blvd., Suite 904
Ft. Lauderdale, FL 33301
305-463-0158

Ken Olsen & Jonny Weiss
Instructors
Sustoinable Technologies International
P.O. Box 1115
Carbondale, CO 81623
303-963-0715

Ed Begley, Jr.
The Sterling Winters Company
1900 Avenue of the Stars, Suite 739
Los Angeles, CA 90067
213-557-2700
(actor, environmentolist and EV owner)

Mary Ann Chapman
Tucson EV Association
P.O. Box 77538
Tucson, AZ 85705
602-888-9645

EV Publications

Robert Morey
Editor
Advanced Battery Technology
P.O. Box 30
Cooperstown, NY 13329
607-547-5314

Autofacts Inc.
The Electric Vehicle Market
1595 Padi Pike
P.O. Box 2389
West Chester, PA 19380
215-429-9900

8ob Martino
8attery Automated Transportation
2471 South, 2570 West
West Valley City, UT 84119
801-977-0119

Anna Crull
Director of Publicatians
Battery & EV Technology News
10101 Fondren Road, Suite 227
Houston, TX 77096
713-774-39426

Clare Bell
Managing Editor
Current EVents
5680 Judith Street
San Jose, CA 95123
408-225-6403

Editor
Electric Car
P.O. Box 6854
Vera Beach, FL 32961

Greg Brown
Editor
Electric Car Magazine
Argus Publishers Corporation
12100 Wilshire Blvd., Suite 250
Los Angeles, CA 90025
213-820-3601

Editor
Electric Vehicle Newsletter
1911 N. Fort Meyer Drive, #703
Arlington, VA 22209

Paul Braus
Editor
Electric Vehicle Progress
215 Park Avenue South, Suite #1301
New York, NY 10003
212-228-0246

Steve McCrea
Editor
EV Newsletter
1402 East La Olas Blvd., #904
Ft. Lauderdale, FL 33301

Joe Stevenson
Editor
Solar Mind
759 South State, #81
Ukiah, CA 95482
707-463-1812

Chapter 4

Ethanol-Powered / Flexible Fuel Vehicles

Ethanol, ethyl alcohol or grain alcohol (CH_3CH_2OH), is a liquid derived from corn or other grain, other agricultural products or waste. This liquid can be used as a high octane fuel in vehicles. More than four million cars run on ethanol in Brazil as a result of a government program to make fuel from sugar cane. The number of vehicles using ethanol is increasing in the United States.

Ethanol vehicle fuel is being tested in the United States in a blend called E85, 85 percent ethanol mixed with 15 percent unleaded gasoline. Farm vehicles have been converted to ethanol, as have light-duty vehicles, which are in testing and demonstration programs. Flexible Fuel Vehicles (FFVs) that operate on methanol and gasoline in any combination from the same tank must be calibrated to run on E85 because of the differences in energy content and other minor differences in the fuels. Most of the technical material and many of the questions and answers in the chapter on methanol also relate to ethanol vehicles.

History of Ethanol

The earliest forms of alcohol were simple fermented beverages. As early as 6,000 to 4,000 B.C., the art of making crude beers and wine was flourishing in the Middle East. The Chinese were probably the first to distill alcohol directly from a fermented (rice) liquor around 800 B.C. By the year 500 A.D., distillation technology had advanced to the point where relatively pure forms of alcohol were used in cosmetics, perfumes and medicines. From the 18th century to the beginning of this century, major discoveries about the chemistry and technology of distillation made it possible to produce ethanol cheaply from a variety of organic materials. In recent history, public interest in alcohol as a transportation fuel has changed with the pattern of war-prosperity-depression cycles and with the price and supply of oil.

Ethanol's history as a transportation fuel goes back many years to Henry Ford and other transportation pioneers. In the 1880s, Ford built one of his first automobiles – the quadricycle – and fueled it on ethanol. As mentioned in the opening chapter, early Ford Model Ts had a carburetor adjustment that could allow the vehicle to run on ethanol fuel that was produced by America's farmers. Ford's vision was reportedly to "build a vehicle affordable to the working family and powered by a fuel that would boost the rural farm economy."

Rising taxes on ethanol limited its use as a fuel, and the lower cost of gasoline and a "propaganda campaign" by the oil producers, however, kept ethanol and other alternatives from ever catching on as transportation fuels. During World War I and II in both the United States and in Europe, alcohol fuels were used in place of oil. For example, vehicle fuels were a mix of 20 percent alcohol and 80 percent gasoline in WWI. In the 1930s, research in the Midwest advocated use of alcohol in gasoline. The Nebraska legislature even passed a two-cent a gallon refund to motorists who would use alcohol blends, but the petroleum industry campaigned to cancel the plan. Once again in WWII, alcohol was used as a blend with gasoline. The government even commandeered whiskey distilleries into alcohol production. Following the war, oil prices dropped to ridiculously low levels, and alcohol was "out" again as a transportation fuel.

Modern Alcohol-Powered Vehicles

The first modern, mass-produced ethanol vehicle was made by the Chevrolet Division of General Motors. A total of 50 ethanol-optimized 1992 model year Chevrolet Lumina Variable Fuel Vehicles (VFVs) were demonstrated in Iowa, Indiana and other states. Chevrolet then produced 320 E85 Lumina VFVs in the 1993 model year. These vehicles can operate on ethanol or gasoline in any combination from a single tank. Other auto companies are also looking at designing fuel-flexible vehicles for E85. Ford built a limited number of E85 Taurus FFVs in 1994 model year and is planning to offer an ethanol-calibrated Taurus Flexible Fuel Vehicle in the 1995 model year for sale in the Midwest.

Ethanol-powered Flexible Fuel Vehicles produce

about 30-50 percent less smog-forming emissions than a similar model gasoline-powered vehicle. Lifecycle greenhouse gas emissions for ethanol, however, may be higher because of production of the feedstock crop. According to one study by the U.S. Environmental Protection Agency, when feedstock and corn-farming practices — fuel for machinery, fertilizer and pesticide production, grain drying and fermentation — are added to a computation of carbon emissions for ethanol, total ethanol production and use emits more than six times the amount of carbon than an equivalent gallon of gasoline. Other studies dispute this claim.

Like all internal combustion engines, vehicles using ethanol emit minor amounts of aldehydes. That concern has been taken care of by installation of advanced catalytic converters.

Ethanol is made from renewable resources — corn and grain feedstocks. Production of ethanol is more costly on a per gallon basis than some other alternative fuels, although government subsidies of about 54 cents per gallon (blender's credit) have kept prices comparatively low. According to trade publications, the December 1994 price for wholesale ethanol (E100) is about $1.03 to $1.30 a gallon. Prices are high because of the demand for alcohol as feedstocks for oxygenates in reformulated gasoline.

Ethanol can be made from biomass – such as municipal waste and other biological materials. In 1992, the National Renewable Energy Laboratory estimated the potential cost of ethanol production from biomass, using its current advanced technology, at $1.22 a gallon. That cost is expected to be lower in the future due to improvements in the technology.

The price of ethanol is also constrained because of the feedstock, which is closely tied to commodity prices for agricultural crops. For example, severe flooding of the Mississippi River in 1993 directly impacted the corn crop in the Mississippi basin, resulting in higher prices. This resulted in a short-term regional ethanol fuel price increase.

The use of ethanol in America has been primarily in the Midwest, where excess corn is distilled into fuel. A high percentage of Midwest service stations, especially in Iowa, offer high octane gasoline blends containing 10 percent ethanol (gasohol).

Ethanol production within California is relatively limited. In 1991, 490 barrels of ethanol were produced per day, or a total of 20,580 gallons per day. This totaled 7.5 million gallons of ethanol a year produced within the state. Most of the ethanol feedstock is from the state's wine industry and from other liquid products, such as cheese whey.

A total of nearly 500 million gallons of gasohol (10 percent ethanol and 90 percent unleaded gasoline) were consumed in California in 1991 — this totaled 50 million gallons of neat ethanol. Gasohol use, however, dropped off dramatically in 1992 when an independent gasoline distributor (Ultramar) stopped selling gasohol, and the amount of ethanol used in the state decreased.

Ethanol consumption is expected to remain stable in California through the end of the decade. A possible increase in California production of ethanol could be realized with the construction of the Sacramento Ethanol and Power Cogeneration Plant (SEPCO). This project north-east of Sacramento combines a power plant that will make electricity for the Sacramento Municipal Utility District with a plant that will use rice straw to produce ethanol. Rice straw is currently burned in the fields at the end of harvest, but air quality restrictions will curtail that burning in a few years. The SEPCO plant is expected to produce about 12 million gallons of ethanol a year, about one-quarter of the 1991 usage in California.

Companies building plants for production of the reformulated gasoline additive methyl tertiary butyl ether (MTBE – made from methanol) are considering building swing facilities that can produce ethyl tertiary butyl ether (ETBE – made from ethanol). Both are additives that can be used in reformulated or oxygenated gasoline to reduce emissions. Ten percent ethanol blends are also being used in some areas of the country as a wintertime oxygenated blend to meet U.S. Environmental Protection Agency air pollution regulations

An ethanol vehicle has about 75 to as much as 90 percent the range of a comparable gasoline vehicle, with the same size fuel tank. This is because the energy content of ethanol is lower (75,000 British thermal units per gallon of ethanol and 105,000 Btu/gallon for E85, compared to 115,400 Btu/gallon for gasoline). Manufacturers have compensated by adding larger fuel tanks in FFVs to counteract the drop in mileage.

Because ethanol is corrosive (due to oxidation), some modifications must be made to engines and the fuel delivery system to protect parts. The cost is expected to be about the same as the FFV option for methanol — originally expected to be $100-$300 when full production line runs are created. Auto companies, however, have not been adding any additional charge for the fuel-flexible option, but this practice may or may not continue in the future.

The nation's first E85 (85 percent ethanol) fueling station opened in La Habra, Orange County, California, in the spring of 1990. It is operated by the California Renewable Fuels Council, which is supporting ethanol research and demonstration programs in California.

Questions and Answers About Ethanol

Adapted from the
California Renewable Fuels Council

What is ethanol and E85? Ethanol, which is sometimes referred to as grain alcohol, is actually 200 proof beverage spirits. As a transportation fuel, ethanol is denatured or made unfit to drink. It is blended with unleaded regular gasoline to make E85 with 85 percent ethanol and 15 percent gasoline.

What is ethanol made from? Most ethanol is produced from corn or other agricultural products such as potatoes – just like whiskey or vodka are made from different products. Ethanol can be made from liquid or solid waste – such as foodstocks, wood by-products or agricultural waste such as rice straw. Any feedstocks that contain sugar, starch or cellulose can be fermented and distilled into ethanol.

Is ethanol produced in California? Yes. California producers of ethanol reclaim liquids that have historically been a waste disposal problem and process them into ethanol and other valuable co-products, such as pet food and cattle feed supplements.

Why is ethanol defined as "RENEWABLE?" Whether ethanol is produced from corn, rice straw or beverage waste, each of these feedstocks will be grown or produced again – therefore, ethanol is a renewable source of energy.

What type of vehicle can operate on E85? Fleet operators can purchase flexible fuel vehicles capable of operating on E85, gasoline or any combination of these two fuels from a single tank. The driver makes no adjustment to the vehicle, which can automatically sense the percentage of alcohol in the fuel tank and adjust the engine's parameters accordingly.

Where can I get more information about ethanol? In California, contact the:

California Renewable Fuels Council
3304 Yorba Linda Blvd., Suite 249
Fullerton, CA 92631
(714) 996-6540

Additional information can be provided by the following or one of the contacts on the next page:

American Biofuels Association
(202) 554-1026

California Renewable Fuels Council
(714) 996-6540

Clean Fuels Developmenr Coalition
(301) 913-9636

Governor of Illinois' Ethanol Coalition
(217) 785-2800

Iowa Corn Production Board
(515) 225-9242

National Corn Growers Association
(314) 275-9915

National Renewable Energy Laboratory
(303) 231-1000

Oak Ridge National Laboratory
Biomass Program (Energy Crops)
(615) 574-7377

U.S. Renewable Fuels Association
(202) 289-3835

Current Ethanol-Powered Vehicles

Vehicle Year	*Model*	*Number Produced or Expected Production*
1992	Chevrolet Lumina E85 VFV	50
1993	Chevrolet Lumina E85 VFV	320
1995	Ford Taurus E85 FFV	500

Ethanol Contacts

Automotive

(See methonol listings in next chapter.)

Government

Pat Fax
Northwest Regional
Biomass Energy Program
Bonneville Power Administration
905 N.E. 11th Ave.
Portland, OR 97232
503-230-3449

Alcohol Division
Production Permit Information
Bureau of Alcohol, Tobocco & Firearms
650 Mossachusetts Ave., N.W.
Washington, DC 20226
518-797-3377

Milton Staackmann
Research Associate
Hawaii Natural Energy Institute
University of Hawaii at Manoa
2540 Dole Street
Honolulu, HI 96822
808-956-2348

Noni Shawn
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401
303-231-1947

John Cushman
Oak Ridge National Laboratory
Biomass Prgm.
Short Rotation Woody Crops
P.O. Box 20008
Oak Ridge, TN 37831
615-574-7377

Jack Ranney
Oak Ridge National Laboratory
Biomass Program – Energy Crops
P.O. Box 20008
Oak Ridge, TN 37831
615-574-7377

Roger Conway
Office Director
U.S. Department of Agriculture
1301 New York Ave., N.W., Room 1208
Washington, DC 20005
202-219-1941

Jeff Alson
National Vehicle & Fuel Emissions Laboratory
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4296

Organizations

Bill Holmberg
President
American Biofuels Association
1925 N. Lynn Street, Suite 1050
Arlington, VA 22209
703-522-3392

Jeff Beller and Julia Deloin
Biofuels America
RD 1, Box 19
Westerlo, NY 12193-9801
518-797-3377

Cindy Hasenjager
Regulatory Affairs Coordinator
California Renewable Fuels Council
3304 Yorba Linda Blvd., Suite 249
Fullerton, CA 92631
714-996-6540

Douglas Durante
Clean Fuels Development Coalition
7315 Wisconsin Avenue,
East Tower – Suite 515
Bethesda, MD 20814
301-913-9636

Patricia Sullivan
Consortium for
Planned Biotechnology Research
1220 Potter Drive, Suite 130-D
West Lafayette, IN 47906
317-494-9334

Dave Laos and Mitch Beaver
Governor's Ethanol Coalition
ENR 325 West Adams, 3rd Floor
Springfield, IL 62704
217-785-2800

Iowa Corn Promotion Board
306 West Tower
1200 35th Street
W. Des Moines, IA 50262
515-225-9242

Mike Bryan
National Corn Growers Association
1000 Executive Parkway, Suite 105
St. Louis, MO 63141
314-275-9915

Eric Voughn
Executive Director
Renewable Fuels Association
One Massachusetts Ave., N.W., # 820
Washington, DC 20001
202-289-3835

Sustainable Farming
REAP - Canada
Box 125, Glenolodale House
Ste. Anne de Bellevue, Quebec
CANADA H9X 1C0
514-398-7743

Chapter 5

Methanol-Powered / Flexible Fuel Vehicles

Fuel and Vehicle History

Methanol (methyl alcohol), often referred to as "wood alcohol" but usually made from natural gas, is another substitute for gasoline as a transportation fuel. Its high octane and performance characteristics, the minor modifications needed to allow gasoline engines to use methanol, and the reduction of reactive emissions have made it a popular choice as an alternative fuel for fleet and private vehicle use.

According to the American Methanol Institute, methanol has been used for more than 100 years as a solvent and a chemical building block to make consumer products such as plastics, plywood and paint. It was first discovered in 1823 by condensing gases from burning wood into a liquid. Consumers use methanol directly in windshield washer fluid, gas-line antifreeze and as model airplane fuel.

Methanol is a clean-burning liquid alternative fuel. Its chemical formula is CH_3OH. A fuel-flexible vehicle using 85 percent methanol and 15 percent unleaded regular gasoline produces one-half of the smog-forming emissions than a comparable gasoline-powered vehicle.

Additionally, M85 has a 50 percent reduction in total toxic air pollutants suspected or known to cause cancer (including acetaldehyde; benzene; 1,3–butadiene), when compared to gasoline. Because methanol can be produced from abundant North American supplies of natural gas, coal or even biomass it offers energy security benefits by being a clean alternative to petroleum-based fuels.

Methanol's power, performance and safety have also made it the fuel of choice for Indianapolis 500 race cars since 1965. A chemical derivative known as methyl tertiary butyl ether, or MTBE, is being used in new reformulated gasolines to reduce exhaust emissions.

Methanol sold for light-duty fuel-flexible vehicles is actually a blend of 85 percent methanol and 15 percent unleaded gasoline, which enhances starting ability in cold weather and safety. Known as M85, this blend is an interim step to the use of M100, or neat methanol, which offers greater air quality benefits. M85 has an octane rating of 102, compared to 92 for premium unleaded and 87 for regular unleaded gasoline. With this higher octane is an increase in engine horsepower of about seven to ten percent, or more, depending on the vehicle.

Because it is a liquid, M85 is convenient and tanks can be filled, like with gasoline. Since, 1978, the California Energy Commission, in association with Chrysler, Ford Motor Company, General Motors, Honda, Mazda, Mercedes-Benz, Mitsubishi, Nissan, Toyota, Volkswagen and Volvo, have sponsored demonstration programs to test M85-powered vehicles in public and private fleets. Two American auto companies are currently offering fuel-flexible vehicles for sale to fleets and the public in the 1995 and the 1996 model years.

The Commission is working with several oil companies — ARCO, Chevron, Exxon, Mobil, Shell, Texaco and Ultramar (Beacon) — to continue operating the 53 methanol fueling facilities throughout California. These can supply M85 to as many as 20,000 vehicles. Under state air quality regulations, more M85 stations will be added as the number of methanol vehicles increases.

Today's Prices for Methanol

The cost of M85 has increased over the last half of 1994 and into 1995 because of unforeseen occurrences in the methanol industry and the demand for methanol as a feedstock for MTBE. The price of a gallon of wholesale methanol from the California Fuel Methanol Reserve was 67 cents in December 1994, although methanol costs only about 30 cents a gallon to produce. It is selling, however, for as much as $2.10 a gallon on the world spot market in late 1994.

Part of the increase is due to price changes in the California Methanol Fuel Reserve. The wholesale price of M100 is based on a calculation that includes a market transition adjustment (33% in 1994) of the difference between the spot market price for methanol on the world market and the methanol threshold price (43¢ per gallon) set by agreement among members of the Fuel Reserve. The world market price is over-inflated because of a number of factors and may remain

above normal for up to 18 months.

There are four main reasons for this, three linked directly to demand: demand for methanol for the building industry for plywoods and glues; demand from the oil industry for methanol to be used as a feedstock to make MTBE - an oxygenate for winter-time and reformulated gasoline; and demand by Brazil, which uses alcohols to fuel its vehicles, to replace ethanol from its sugarcane industry that was hard hit by bad weather. The fourth reason for the high prices is that a major methanol production plant (which produced seven percent of the U.S. supply) was heavily damaged in a fire. Couple increased demand and a decreased supply and you have higher prices.

Added to the wholesale price of methanol of 67 cents are the current federal, state and local taxes; transportation charges; cost of gasoline added to the methanol to make M85; and the dealer margins. Dealer "margins" (the charge service station dealers add to the cost of the fuel) may be as high as 20 to 25 cents a gallon (or more) because of the low volume of sales at some stations. Dealers must pay for their shipments after they've been received, not after they sell out a 10,000 gallon tank. Add these all together, and drivers of methanol-powered vehicles are seeing pump prices of $0.919 to $1.20 per gallon. This equates to a gasoline gallon equivalent price of $1.47 to $2.04 per gallon (based on energy content of 1.7 gallons of methanol equal to a gallon of gasoline).

The California Energy Commission estimates, however, that the high prices with methanol should come down as new methanol production facilities come on line and as other factors stabilize. The Commission estimates that these problems could last through 1995 and perhaps into 1996. Gasoline prices, however, are also expected to go up because of the introduction of reformulated gasoline, which costs more to produce. So, the prices should draw closer over time.

The Commission is also working with methanol producers to establish a long-term price for transportation fuel methanol that is not linked to world market prices for a chemical. That price could be in the 50¢ to 60¢ per wholesale gallon range, which still offers methanol producers a good profit and will not cripple an infant alternative fuel industry.

The forecast for methanol prices in the future is much better. The Commission forecasts the M85 price in the year 2010 will be $1.27 for a gasoline gallon equivalent, compared to gasoline priced at $1.48 a gallon. Diesel fuel is forecast at $1.24 a gallon.

Because it takes about 1.7 gallons of methanol to provide the same amount of energy as a gallon of gasoline, methanol vehicles have less mileage range than their gasoline equivalents. Larger fuel tanks and the ability to use unleaded gasoline in these fuel-flexible vehicles — which run on methanol, gasoline, or any combination of the two from a single tank — provide extended range when necessary.

Methanol Vehicles Hit the Roads

By the end of 1994, approximately 10,500 cars, along with about 500 buses and trucks, were running on methanol in California (more than the rest of the country combined). That total is expected to increase as fuel-flexible vehicles (FFVs) and additional heavy-duty methanol-powered engines become more commonplace.

The Energy Commission has been testing alcohol-powered vehicles since 1978. But it was only in the mid-1980s when the fuel-flexible vehicle technology was created, first by Ford and followed closely behind by GM, that the number of vehicles began to increase dramatically. More than 31 million miles have been driven in California in these early model alcohol-powered vehicles. It was not until the 1990s, however, that the vehicles were available for sale to fleets and the general public.

Ford

Ford first produced a flexible fuel vehicle (FFV) in 1987 when it designed a few *Crown Victoria LTD* models to run on methanol or gasoline in any combination. Between 1987 and 1989, the company produced about 200 *Crown Victoria* FFVs which were used in various public fleet demonstration programs. In 1991, Ford produced 178 *Taurus* FFVs, and in the following year, 183 1992 Ford *Econoline* FFV vans were put into service.

In 1993, Ford produced 2,500 1993 flexible fuel *Tauruses*, 2,137 of which came to California. The *Taurus* was the first FFV to be certified by the California Air Resources Board as a Transitional Low Emission Vehicle (TLEV). The 1993 *Taurus* FFV was offered as an option from auto dealers beginning in the fall of 1992 and a number of sales were made to members of the general public.

Ford sold 2,500 Taurus FFVs in its 1994 model year (more than 2,200 in California) and has commitments for all of its 1995 model year FFVs (approximately 1,900). Company officials have indicated that they could produce up to 30,000 flexible fuel Tauruses in the 1996 model year, if there were enough orders. Orders for the 1996 model year Taurus FFV can be placed throughout 1995 like a regular

option, instead of ordering only during a window period.

Hertz Rent-A-Cars, a subsidiary of Ford, and other car rental companies may eventually help put FFVs in the hands of the public more than many other efforts. Following a pilot program by Avis with 20 Chevrolet Luminas, three auto rental car companies in Sacramento each purchased 100 Ford *Taurus* FFVs, with assistance from a Sacramento Metropolitan Air Quality Management District program. The use of FFVs in rental fleets was a resounding success and the companies purchased additional FFVs in 1994.

Hertz announced in November 1994 that it was purchasing 400 1995 *Taurus* FFVs for use at its airport rental fleets in the Los Angeles area. The company is also installing methanol refueling tanks and dispensers at four airport locations to fuel the vehicles with M85. Hertz officials say they would like to buy as many as 3,000 *Taurus* FFVs a year in California, if Ford would make them. Many of these cars would then be available for purchase by the public or other fleets following their six-month rental lifespan.

General Motors

Following a test fleet of 20 Chevrolet *Corsicas* in 1988 and 212 1991 model year Chevrolet Luminas in 1991, in November 1991, General Motors and the Energy Commission announced the availability of Chevrolet Variable Fuel Vehicle (VFV) *Luminas* for purchase by public and private fleets as well as members of the general public. A total of about 1,200 Luminas were sold to California fleets in early 1992. Chevrolet again offered the VFV option with the 1993 model year *Luminas.*

Because of a major body redesign of the *Lumina,* VFVs were not offered in the 1994 and 1995 model years. It was reported by some news media that Chevrolet was considering offering a compact vehicle (*Corsica*-size) and a light-duty pickup truck (Chevrolet *S-10*) with variable fuel / methanol option in the 1996 model year, but the auto company has yet to make an announcement about future methanol-powered vehicles.

Chrysler

At the 1991 Greater Los Angeles Auto Show, Chrysler announced that it would build 2,500 1992 model year, "A-body" cars (Plymouth *Acclaims* and Dodge *Spirits*) to run on methanol. The flexible fuel vehicles were offered for sale in California to fleets and the public. The flexible fuel /methanol option was offered to the purchaser at no extra cost. With government incentives, this made the Chrysler FFV less expensive than a gasoline-only model. The other auto companies followed suit, charging nothing extra for the FFV option.

Chrysler later announced that nearly all of the 910 1993 model year *Acclaims* and *Spirits* were purchased by the United States General Services Administration, out of a total of 1,119 that came to California. All Chrysler Spirit/Acclaims FFVs were certified as Transitional Low Emission Vehicles by the California Air Resources Board.

In the 1994 model year, Chrysler again sold nearly all of its *Acclaims* and *Spirits* to the U.S. GSA. Chrysler's 1994 LH series (Chrysler *Concord,* Dodge *Intrepid* and Eagle *Vision*), were offered with the methanol option. Because it was not certified by the California Air Resources Board, however, the flexible fuel LH was not offered in California in 1994, except for a few experimental models.

Chrysler is again offering its Dodge *Intrepid FFV* in the 1995 model year, CARB-certified as TLEV. The company may consider offering the flexible fuel option on the *Stratus* or *Cirrus* models, which replaced the *Acclaim* and *Spirit* in Chrysler's line up. The company, however, has made no announcement of its future intentions for FFVs.

Foreign Auto Companies

Foreign auto companies are also working on fuel-flexible vehicles. Volkswagen has produced more than 50 fuel-flexible *Jettas* in the early 1990s. Honda, Mazda, Mercedes-Benz, Mitsubishi, Nissan, Toyota and Volvo have all produced a limited number of demonstration or experimental vehicles. It is unknown what marketing plans foreign car companies have for their flexible fuel vehicles.

Questions and Answers About M85 and Flexible Fuel Vehicles

Questions About the Vehicles

What is a fuel-flexible vehicle? Do you have to switch between methanol and gasoline? Are they in separate tanks? A fuel-flexible vehicle is specially designed by an auto manufacturer to use methanol or regular unleaded gasoline in any combination from a

single tank. The vehicles have a special sensor on the fuel line that can detect the ratio of methanol to gasoline that is in the tank. The sensors tell on-board computers about the fuel mixture, and the computer automatically adjusts the vehicle's fuel injection and ignition timing to compensate for the different fuel mixtures.

What happens when methanol is not available? The fuel-flexible option allows the driver to use any combination of gasoline or methanol — from 100 percent unleaded gasoline to 85 percent methanol. A driver can therefore use unleaded gasoline if methanol is not available.

What are the differences in a fuel-flexible vehicle compared to a regular gasoline-powered model? Are different parts used? There is only one major additional part that is included on a fuel-flexible vehicle — the fuel sensor that detects the methanol/gasoline ratio. Some other parts on the fuel-flexible vehicle's fuel-delivery system need to be changed to handle methanol. Alcohol is corrosive, especially to rubber and plastic parts. Hence parts that are tolerant to alcohol fuels must be substituted on the auto manufacturers' assembly line for parts that will come in contact with the alcohol fuel.

Is the trunk space of the car affected by using methanol? Unlike compressed natural gas or propane, no additional fuel tank is needed for methanol. Because a fuel-flexible vehicle is fueled just like a gasoline vehicle and has only one tank, trunk space is not compromised.

What is range of fuel-flexible vehicles? Is the mileage lower for fuel-flexible vehicles? Methanol has about half the energy content of gasoline. With current engine technology, a vehicle needs about 1.7 gallons of methanol to go the same distance one gallon of gasoline will take the vehicle. The range of a fuel-flexible vehicle is dependent on the tank size and driver fuel efficiency techniques. The distance a fuel-flexible vehicle can go depends on a number of factors. Some auto manufacturers will be increasing the fuel tank size in their fuel-flexible vehicles. Ford Motor Company is equipping its newer fuel-flexible vehicles with a 20 gallon fuel tank instead of a 16 gallon tank. Vehicles tested have a range of 200 to 400 miles depending on tank size.

What is the price of the fuel-flexible option on a vehicle? When the cars are mass-produced, the estimated cost for the fuel-flexible option is about $250 per vehicle or less. Chevrolet, Chrysler and Ford, however, have offered the methanol option at no additional cost to the consumer. That may change in the future depending on the auto company. With incentives from the California Energy Commission and local air quality districts, the methanol-powered cars can actually cost LESS than gasoline-only models.

Do FFVs qualify for a federal or state tax credit or deduction? If there is no incremental (additional) cost to allow the FFV to run on alcohol fuel, above the price of a comparable gasoline model, then the vehicle does not qualify for a credit or deduction.

Can a car be retrofitted to use methanol? Yes. A car can be retrofitted, but there may be no air-quality or emissions benefits from doing so, and there are no methanol conversion kits certified by the California Air Resources Board. So, even though a car could actually be converted, it is not practical to do so and may not meet emission regulations. Fuel-flexible vehicles are specially suited to burning methanol as efficiently as possible and run cleaner than using gasoline. Switching a regular car to methanol would require special adjustments to or changes in the vehicle's computerized fuel injection system. This could not be done by the average person.

Are the vehicles covered by factory warranties? The fuel-flexible vehicles are completely covered by the original equipment (auto company) manufacturers' factory warranties. Some auto companies even offer extended warranties. Ford's 1993 Taurus, for example, had a six year /60,000 mile warranty. Methanol equipment is often given a lifetime warranty.

Are repairs and maintenance costs for fuel-flexible vehicles any different? No. The costs are roughly the same as regular auto repairs and maintenance. A fuel-flexible vehicle does run cleaner, so some maintenance costs may actually be reduced in the long run.

Is a special oil needed for the vehicle? Does it cost more? A special lubricant additive with enhanced acid-neutralizing capabilities is used in current models. Oil changes are recommended every 3,000 to 6,000 miles, depending on model. Because this special oil is produced in limited qualities, it is more expensive than regular oil. The Energy Commission has been working with auto makers to price the oil at a reasonable cost.

Questions About the Fuel

What is methanol? Methanol is methyl alcohol, commonly known as "wood alcohol." It is a colorless,

flammable liquid, with the chemical formula CH_3OH. For more than 100 years, methanol has been used as a solvent and chemical building block to make consumer products such as plastics, plywood and paint. Its primary market is formaldehyde urea glue used in building products. It is also used as a gas line antifreeze, model airplane fuel, in windshield washer liquid, general solvent, as a racing fuel, and as a feedstock in the petrochemical industry.

Methanol is mandated as the only fuel that is used on the Indy Car racing circuit. Back in 1964, the Indianapolis 500 race suffered a horrendous pile-up of cars and resulting gasoline fire and deaths. That was the last time gasoline was used to power a vehicle at an Indy-type race.

Professional Indy driver Scott Brayton (quoted in the Canadian Oxygenated Fuels Association's Methanol News) says: "Methanol has been the preferred racing fuel for (three) decades. It is one of the cleanest-burning fuels, with a high flash point. In the event of an accident, a methanol fire can be extinguished with water...while water on gasoline spreads the fire. Methanol provides a racing car with high performance, while acting as a coolant. It helps us get those jack rabbit starts — acceleration from zero to 100 miles an hour in under three seconds."

How is methanol produced? Methanol can be produced from just about anything containing carbon, including natural gas, coal or biomass. Currently, abundant North American supplies of natural gas are used as the feedstock source of methanol. Typically, methanol is produced using steam and pressure, and a catalyst that converts natural gas, or methane, into the liquid methanol. Methane gas (a greenhouse gas) given off by decomposing vegetable matter in landfills may also be tapped as a source for methanol production. A research and demonstration project in Southern California funded by the Energy Commission and the South Coast Air Quality Management District will use biomass to produce methanol in what is known as the Hynol process.

What fuel is used in the fuel-flexible vehicles? M85 is the fuel available at designated retail outlets to use in FFVs. M85 is a mixture of 85 percent methanol and 15 percent regular unleaded gasoline. The gasoline is added to provide color to a flame, should there be a fire involving M85, and to assist in vehicle-starting during colder weather. The gasoline also adds a smell and color to the clear, odorless methanol to prevent possible misuse.

Does M85 have lower exhaust emissions when compared to gasoline? Vehicles using M85 produce 30 percent to 50 percent less of the smog-forming emissions than regular unleaded gasoline used in a comparable vehicle. Emissions of nitrogen oxides and hydrocarbons are less than gasoline; but emissions of carbon monoxide are equal or slightly higher. Reformulated gasoline is expected to be about 30 percent cleaner than today's gasoline, so "reformulated M85" (85 percent methanol and 15 percent reformulated gasoline) should have even lower levels of smog-forming exhaust emissions.

How does M85's octane rating compare to gasoline? M85 is a high-performance liquid fuel with a pump octane rating of 102, compared to 92 octane for premium unleaded gasoline and 87 for regular unleaded gasoline.

Is there an increase in vehicle performance with M85? Using methanol in a fuel-flexible vehicle increases the horsepower by about 7-10 percent, or more, depending on the vehicle.

Is M85 more toxic or dangerous than gasoline? All motor vehicle fuels are toxic or dangerous. The same precautions used with gasoline must be taken when using M85. M85, like gasoline, should not be ingested as it can be fatal, and persons should not siphon methanol from a tank. If M85 is splashed on the skin, it should be washed off immediately. Clothing should be changed and laundered as soon as possible if M85 is spilled on them.

According to the U.S. Environmental Protection Agency, in minute amounts, methanol can be safely metabolized by humans. It is naturally found in low levels in many fruits and fruit juices. It is also a "breakdown" product of some artificial sweeteners used in soft drinks.

On the plus side, pure 100 percent methanol contains none of the carcinogenic "ingredients" of gasoline like benzene, 1.3 butadiene and acetaldehyde. M85 (with 15 percent unleaded gasoline) contains a lesser amount of these carcinogens. The EPA says methanol is not a carcinogen, reproductive or mutagenic hazard, and not a threat to a fetus.

What about formaldehyde? All internal combustion engine vehicles today emit some amount of formaldehyde. With new catalytic converter technology, the amount of formaldehyde emitted by a fuel-flexible vehicle is reduced dramatically. Research by the prestigious Carnegie Mellon University indicates that formaldehyde emissions can be kept in check by catalytic converter technology. The California Air

Resources Board has established a formaldehyde emissions standard for all motor vehicles. The FFVs sold in California meet CARB's stringent standard for formaldehyde.

If M85 is spilled on the ground, can it contaminate ground water? Methanol is water-soluble and, as such, could be quickly diluted in large bodies of water to levels which are safe for organisms. M85 spills should not lead to environmental effects worse than petroleum fuels, and in many cases the recovery rates are faster. While the behavior of M85 spills continues to be a valid research topic, it is more important to determine cleanup procedures for M85 or M100 methanol spills. Current regulations for underground fuel storage tanks require that the tanks be double-walled. The likelihood of an undetected leak of M85 or any other fuel occurring from these tanks is extremely small.

Is there a fire hazard with M85? M85 like any other fuel is flammable. According to the U.S. Environmental Protection Agency, compared with gasoline, M85 results in much lower frequency of vehicle-related fires and a lower hazard to people and property, should a fire occur. M85 is more difficult to ignite than gasoline because of its high flash point, and if ignited, M85 burns in a more controlled manner with less heat than other transportation fuels.

What is the difference between M85 and Gasohol? Gasohol is a blend of unleaded gasoline and 10 percent ethanol — ethyl or "grain" alcohol. M85 is a blend of 85 percent methanol and 15 percent unleaded gasoline.

Will I hurt a regular gasoline vehicle if I use M85? Yes. Vehicles not specially outfitted to use methanol can be damaged. Damage is usually to parts susceptible to corrosion — rubber and plastic hoses, etc. Gasoline vehicles using even a small amount of methanol may be rendered inoperable.

What mileage can you get with M85? It takes 1.7 gallons of M85 to equal a gallon of gasoline. A mid-size car with a 16 gallon tank can travel 424 highway miles on gasoline and 265 miles on methanol (based on 26.5 m.p.g. on gasoline).

What is the price of M85?

The price of 100 percent methanol through the California Fuel Methanol Reserve in December 1994 was 67 cents per gallon. M85 costs between $0.919 and $1.20 cents per gallon retail (depending on the retail outlet selling M85). The additional cost includes transportation charges, the cost of the 15 percent unleaded gasoline when the product was delivered, dealer margin or profit (normally 10% of wholesale price but can be up to 20 to 25 cents per gallon – or more) and taxes. Because it takes 1.7 gallons of M85 to equal a gallon of gasoline, this works out to $1.47 to $2.04 cents per "gallon equivalent." (Please see discussion about methanol prices in previous section.)

Questions About Methanol and the California Methanol Fuel Reserve

Where does California get its methanol for the fuel demonstration program? Since the program's creation, methanol has been produced for California's demonstration program from natural gas by a number of companies including: Beaumont Methanol Corporation, Enron Petrochemicals Company, Hoescht Celanese Chemical Group, Intermountain Chemical Inc., Methanex Corporation and Novacor Chemical USA. Methanex holds the current contract in California to supply an annual total of 21 million gallons of methanol for the state's fuel methanol reserve. The company delivers the methanol to storage areas in Northern and Southern California. From these areas it is mixed with unleaded regular gasoline and transported to retail network participants.

Who sells M85? Under 10-year agreements with the Energy Commission, ARCO, Chevron, Exxon, Mobil, Shell, Texaco and Ultramar (Beacon) have agreed to participate in the Methanol Retail Fuel Supply Network. (See Chapter 10 for locations.) Other oil companies have expressed an interest in retailing methanol. The oil companies install, operate and maintain the M85 equipment at their stations throughout California. The Energy Commission supplies the methanol fuel storage and dispensing equipment. A number of private companies and government agencies have their own private methanol fueling facilities.

Where can M85 be purchased? In December 1994, M85 could be purchased at 53 retail service stations. Many of these sites are in Southern California. Additional stations would be added as the number of vehicles needing M85 increases. As soon as 20,000 certified FFVs are on the road, a California Air Resources Board regulation will require oil companies to phase in 400 additional M85 fueling facilities in California over a five year period. The stations are divided by market share between the oil companies.

Are these regular service stations? Yes. Because of the need to expand the public availability of M85, the Energy Commission encourages that M85 usually be sold by stations owned and operated by an oil company. There are also private methanol fueling stations at various light-duty fleet yards, transit agencies and at school districts using methanol-powered buses, but these are not open to the public.

Where are these stations located? The stations are located in close proximity to fleets operating fuel-flexible vehicles. Usually about 30 to 50 fuel-flexible vehicles are needed in any given area to justify a fueling location. Most of these stations are strategically located along well-traveled thoroughfares such as interstates or freeways. Under an agreement with Caltrans, logo signs displaying a fuel dispenser with a letter "M" on it and the word "Methanol" are located along freeways and surface streets to direct motorists to the methanol station. In addition, the Energy Commission publishes a Methanol Fueling Guide, a small loose-leaf binder with maps locating all M85 fueling stations in California. This binder is updated regularly.

Does a service station need a special M85 tank below ground? Because the fuel is "corrosive" to rubber, some metals and certain plastics, special methanol-compatible storage facilities, tanks, hoses, pumps and parts are needed. It is estimated that more than 800-900 tanks at service stations in California are methanol tolerant. Some local air quality districts require that newly installed double-walled tanks and equipment are methanol-compatible.

What is the cost of installing M85 fueling equipment? Can one be installed for a public or private fleet? The cost for dispensing equipment is roughly $35,000 at oil company owned and operated facilities. An in-ground tank can cost about another $45,000. Private fleets may put in their own methanol fueling facility, and the Energy Commission offers help with design plans and equipment specifications. Private facilities, however, must provide documentation of maintaining M85 purity. If a below-ground tank is already methanol-compatible, the cost for installing the equipment is substantially less.

How is the fuel system accessed? Currently, the M85 pumps are equipped with credit card, ATM-style electronic readers maintained and billed by Chevron. The Card is similar to an electronic automated teller banking card but is good only for dispensing methanol. This prevents unsafe fueling of gasoline vehicles with methanol. Chevron bills the fleets directly for the methanol dispensed, provides a written print out of vehicle fuel usage, including mileage to help compute miles-per-gallon, and then pays each oil company directly. This rids a fleet owner of having to deal with separate oil company credit cards and allows one single monthly payment, no matter which oil company the M85 is purchased from. In the future, oil companies will probably offer M85 through their own credit card systems, so a Visa or Mastercard could be used. Research is also underway to develop a different filler nozzle for methanol pumps that cannot be used in regular gasoline-only vehicles (similar to the leaded gasoline nozzles that could not be used in unleaded gasoline-fueled vehicles) to prevent misfueling.

Methanol Vehicles in California

Previous Methanol & Flexible Fuel Vehicles Sold

1982-1987 Ford Escort "dedicated" methanol vehicle	500
1987-1989 Ford Crown Victoria LTD FFV	218
1988 Chevrolet Corsica VFV	20
1991 Chevrolet Lumina VFV	212
1991 Taurus FFV	178
1991 Volkswagen Jettas	50
1992 Chevrolet Lumina VFV	1,192
1992 Chevrolet Lumina VFV (E85*)	50
1992 Chrysler Spirit/Acclaim FFV	700
1992 Ford Econoline Van FFV	183
1993 Chevrolet Lumina VFV	75
1993 Chevrolet Lumina VFV (E85*)	320
1993 Chrysler Spirit/Acclaim FFV	1,119
1993 Ford Taurus FFV	2,137

* Vehicles sold in Midwest for demonstration fleets using Ethanol.

Currently Available Methanol-Powered FFVs

1994 Ford Taurus M85 FFV*	2,257 (sold)
1994 Chrysler Spirit/Acclaim FFV	1,690 (sold)
1994 Dodge Intrepid FFV	(limited number produced)
1995 Ford Taurus M85 FFV	1,940 (sold out)
1995 Dodge Intrepid M85 FFV	300 (sold), up to 3,000 may be produced
1996 Ford Taurus M85 FFV	3,000 firm/up to 30,000

(* Note: Some 1994 models may be available as used vehicles from car rental company resale outlets.)

Methanol-Powered Flexible Fuel Vehicle Contacts

Auto Makers

A. Michael Clement
Alternative Fuels Vehicle Marketing
Chrysler Corporation
12000 Chrysler Drive
CIMS 414-03-44
Highland Park, MI 48288
313-956-4599

Michael Coates
Western News Bureau
Chrysler Corporation
601 West 5th Street, 4th Floor
Los Angeles, CA 90071
213-622-1644

Lou Ulrich
Account Executive
Fleet Sales Dept.
General Fleet Office
Ford Division
2099 South State College Blvd.
Suite 600
Anaheim, CA 92816
714-939-3562

W.J. "Bill" Boultes
Account Executive
Fleet Sales Dept.
General Fleet Office
Ford Division
P.O. Box 9048
Pleasanton, CA 94566
510-463-5791

Ford Motor Company
Alternative Fuel Vehicle Hotline
1-800-ALT-FUEL (258-3835)

Gerald J. Barnes
Manager
Automotive Emissions Control
General Motors Corporation
3044 West Grand Blvd.
Detroit, MI 48202
313-556-7723

Fuel Providers

Ray Lewis
Executive Director
American Methanol Institute
815 Connecticut Ave., N.W.,
Suite 800
Washington, DC 20006
202-467-5050

California Fuel Methanol Reserve
Card-Key Access
Judy Bruns
Chevron Products Company U.S.A.
P.O. Box 9560
Concord, CA 94524-9875
800-554-1376

Government Agencies

California Energy Commission
Transportation Technology & Fuels Office
1516 Ninth Street, MS-41
Sacramento, CA 95814
916-654-4634

Ruth Anne Keister
Clean Cities Hotline
P.O. Box 12316
Arlington, VA 22209
1-800-C-CITIES
703-528-1953

Linda Bluestein
Contract Manager
National Alternative Fuels Hotline
P.O. Box 12316
Arlington, VA 22209
800-423-1DOE (1363)
703-528-1953

National Appropriate Technology
Assistance Service (NATAS)
P.O. Box 2525
Butte, MT 59702
800-428-2525

Greg Dolan
New York State Energy Research &
Development Authority
Two Rockefeller Plaza
Albany, NY 12223
508-465-6251 ext 226

Lionel Vera
Director, S.F. Regional Support Office
U.S. Department of Energy
1301 Clay Street, Suite 1060-North
Oakland, CA 94612
510-637-1945

Jeff Alson
National Vehicle
& Fuel Emissions Laboratory
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4296

Tad Wysor
Clean Fuel Fleets Program
U.S. Environmental Protection Agency
2656 Plymouth Road
Ann Arbor, MI 48105
313-668-4332

David Gushee
Senior Specialist, Environmental Policy
U.S. Library of Congress
Congressional Research Service
Washington, DC 20540
202-707-7228

Organizations

E. Eugene Ecklund
Executive Director
Alternative Transportation Fuels
Foundation
HCR-72, Box 547-8 LOW
Locust Grove, VA 22508
703-972-0484

Peter Baljet
Chairman
American Lung Association
National Air Conservation Commission
9350 South Dixie Highway, #1540
Miami, FL 33153
305-670-6774

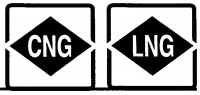
Michael McNeil
Canadian Oxygenated Fuels
Association
190 Bronson Ave.
Ottawa, CANADA K1R 6H4
613-232-9729

Wayne Parker
General Manager
Clean Air Vehicle Association
14 Piedmont Center, Suite 1205
Atlanta, GA 30305
404-237-1980

David P. Lefever
Executive Director
National Assn. of Fleet Administrators
120 Wood Avenue South, Suite 615
Iselin, NJ 08830
908-494-8100

L. Donald Shields
Coordinator, Project California
California Council
on Science & Technology
100 Academy Drive
Irvine, CA 92715
714-854-4150

Chapter 6
Natural Gas Vehicles



Fuel and Vehicle History and Characteristics

Of all the liquid or gaseous fuels ready for commercial transportation use, compressed natural gas (CNG) and liquefied natural gas (LNG) offer the largest reductions in emissions compared to gasoline: carbon monoxide is reduced by 65 to 90 percent, particulates are virtually eliminated, and the ozone reactivity from natural gas vehicles is up to 80 to 90 percent better than gasoline emissions.

A practical gas engine was developed and built by Etienne Lenoir of France in 1860 that ran on illuminating gas from coal. The gas was stored in a rubber bladder. In 1862, he built a vehicle powered by one of his engines.

The natural gas vehicles today have come a long way. CNG is being used in California in light-duty passenger vehicles and pickup trucks, medium-duty delivery trucks, and in transit and school buses. LNG is being looked at favorably for heavy-duty applications, such as transit buses, and other transportation applications, such as locomotives and long-haul semi-trucks. The California Energy Commission is working with local governments and natural gas utility companies to demonstrate various vehicles in daily applications and to help commercialize this clean fuel.

Natural gas vehicles are expected to help auto companies meet the state Air Resources Board mandates for Low Emission Vehicles and Ultra-Low Emission Vehicles, which take effect in 1997. And because there are abundant North American supplies of natural gas, use of CNG to replace gasoline will help reduce the country's dependency on petroleum.

Natural gas vehicles (NGVs) are more common abroad. Italy has about 300,000 natural gas-powered vehicles; the former Soviet Union has an estimated 250,000; New Zealand has more than 150,000; Australia has some 75,000; and Canada has more than 20,000. According to the American Gas Association, there are an estimated 35,000 NGVs operating in the United States. By the end of May 1992, there were more than 800 NGVs in utility company and other fleets in California. By May 1994, the natural gas utility companies estimate that this number jumped to about 3,500. By the end of 1994, that increased to more than 6,000.

The cost of equipping a light-duty vehicle to run on compressed natural gas can range from about $2,500 up to about $5,000, depending on the vehicle and number of cylinders to store the fuel. California and the federal government offer various incentives for natural gas vehicles to help reduce this cost. During 1994, the Energy Commission offers a limited amount of fund toward $1,000 "rebates" for a vehicle that is certified by the Air Resources Board as a Low Emission Vehicle. The Commission offers a $1,500 "rebates" for an Ultra-Low Emission Vehicle. These "rebates" are available directly from the state's three main natural gas utility companies — Pacific Gas and Electric, Southern California Gas, and San Diego Gas & Electric. The Energy Commission will offer incentives again in 1995 (probably for ULEVs).

CNG ranks relatively high in convenience and availability. California's extensive network of natural gas pipelines can deliver the fuel directly to many sites where compressors are installed by the local utility, including individual homes. Two types of fueling systems are available for commercial use: a "quick fill" system that fuels a vehicles in five minutes (similar in time to fueling a vehicle with gasoline), or a "slow fill" system that can fuel an entire fleet overnight. CNG may be the preferred clean, alternative fuel for fleet use where vehicles travel specified routes, such as delivery trucks, and return to a central yard where they can be slow-filled overnight.

Costs for a "slow fill" system or "quick fill" system to handle public or private fleets can cost $250,000 or as much as $3 million for a bus fleet. A compressor station typically costs $2,000 to $4,000 per vehicle served. Refueling can be done easily by trained drivers. Costs for a compressor for use with a single vehicle in private homes averages about $3,500. Individual home compressors use a slow-fill system for overnight refueling. The small compressor would usually be located in a home's garage area and would be connected directly to the natural gas supply in the house.

There are currently 124 public and private natural gas vehicle fueling facilities in California, 78 of which are open for public use. As natural gas usage increases, new stations will be added by tapping into the existing municipal natural gas main system. Chevron, Shell, Texaco and Unocal have entered into agreements with natural gas utility companies to dispense CNG at various gasoline stations. Some private companies are also selling CNG, including FleetStar and MESA.

Automobile manufacturers are developing dedicated CNG engines that are extremely clean, which should lower capital vehicle costs and create further improvements in efficiency. Conversions of gasoline-powered vehicles to CNG are also possible with kits certified by the California Air Resources Board (see list below of certified vehicles). Conversion of vehicles also creates jobs for local economies and vocational education opportunities for high schools and community colleges.

The cost of CNG conversion runs from about $2,000 to about $5,000 depending on the vehicle and the number of cylinders. Converted vehicles, however, may not be covered by auto manufacturers' warranties and may not be qualified for various state or federal incentives or tax credits.

CNG's biggest drawback remains its reduced range of 120-180 miles for the average vehicle with three cylinders. Newer technology vehicles have been recently demonstrated, however, that reportedly have a range of up to 300 miles, such as the CNG Honda *Civic* now being tested in the state. Bi–fuel vehicles that can operate on gasoline or natural gas at the flick of a switch, or use an automatic switching system, are available when extended range is necessary — though bi–fuel vehicles may have higher average emissions than dedicated natural gas vehicles. Advanced designs optimized for CNG are expected to routinely provide ranges of 300 miles or more for passenger cars.

Secondly, because of the gaseous nature of the fuel, the time of day and the ambient air temperature can affect the amount of fuel that can be compressed into a tank. For example, if drivers filled the cylinders on a hot afternoon, drove home and parked overnight; they would find the cylinder not totally full in the cool of the morning. The heat would have expanded the gaseous fuel during the hot afternoon so that the cylinder registered only 75 to 85 percent full in the morning. CNG retailers are working to correct this situation.

Questions and Answers About Natural Gas Vehicles (NGVs)

What is a Natural Gas Vehicle? Can you switch between natural gas and gasoline? A Natural Gas Vehicle (NGV) is a vehicle that operates on compressed (CNG) or liquefied natural gas (LNG) in a vehicle dedicated to run only on that fuel, or one that operates on both natural gas and gasoline (called a dual-fuel or bi-fuel vehicle). Bi-fuel vehicles usually have a switch located on the dash that lets the operator choose between the two fuels. Some bi-fuel vehicles have an electronic switch that will automatically change from natural gas to gasoline, but only when the natural gas is nearly depleted.

What happens when compressed natural gas (CNG) is not available? A dedicated CNG vehicle must be close to a refueling facility to refuel. With a bi-fuel vehicle, if CNG cannot be accessed, then regular gasoline may be used by switching the vehicle over.

What are the differences between an NGV and a regular gasoline-powered model? Are different parts used? The primary difference is in the fuel storage and intake system. Natural gas vehicles hold the gas in high pressure cylinders. From here, the gas travels along a high pressure fuel line leading to the engine compartment. With bi-fuel vehicles, the CNG tanks and lines are in addition to the conventional gasoline components.

Is the cargo space of the vehicle affected by using CNG? On dedicated vehicles the trunk space is only slightly affected, if at all. The cylinders are usually secured to the bottom of the vehicle to avoid any inconvenience they may cause. On bi-fuel vehicles, the gasoline tank is left in place. Because of this, trunk or cargo space is reduced because of the additional room required for the cylinders.

What is the range of a natural gas vehicle (NGV)? Range depends on cylinder volume, engine size and driving habits. On average, a current model NGV can achieve a range of 120-180 miles. That range was recently extended in special Geo *Prism* and Honda *Civic* prototypes that reportedly can go 300 miles. The *Prism* did so while retaining 80 percent of its cargo/trunk capacity.

Is the mileage lower for NGVs? What mileage can be achieved with CNG? Beginning January 1, 1995, CNG will be sold in California in units that are the

equivalent of a gallon of gasoline, rather than in therms of CNG (which have slightly less energy content than a gallon of gasoline). Hence the mileage of a "gasoline gallon equivalent" with a properly adjusted NGV should be roughly the same as conventional gasoline vehicle. Mileage on a bi-fuel NGV will probably be slightly lower than a conventional gasoline-only vehicle On a dedicated NGV mileage may even increase because the vehicle's compression ratio is changed to take advantage of natural gas' 130 octane rating.

What automobile/engine manufacturers are participating in the production of NGVs? GMC/Chevrolet, Chrysler and Ford have all produced NGVs. Several heavy-duty vehicle engine manufacturers have built engines to use CNG for buses, trucks and other heavy-duty vehicles. Some foreign car companies are also working on natural gas-powered vehicles. (See list below.)

What NGVs are available to be purchased? American automobile manufacturers have natural gas vehicles on the market and ready for sale. Please see below for list of vehicles. (See attached list.)

How many NGVs are there in California and elsewhere? As of December 1994, there were more than 6,000 NGVs on California's streets and highways. Nationally, there are an estimated 35,000 NGVs. NGVs are more common abroad. Italy has about 350,000 NGVs; the Soviet Union has an estimated 250,000; New Zealand 150,000; Australia has some 75,000, and Canada has more than 20,000.

What will be the price of the CNG option on a vehicle? Chrysler charges about $4,000 more for a natural gas vehicle than a gasoline-only model. GMC charged approximately $3,700 more than a gasoline vehicle, but these figures may vary depending on vehicle and number of fuel cylinders. Original Equipment Manufacturers are working with the natural gas industry to reduce the differential cost to only $2,000 within three years by exploring CNG-optimized designs.

Can a vehicle be retrofitted to use CNG? Yes. The natural gas utility companies all have programs to assist fleet operators and individuals in conversion of gasoline vehicles to CNG. Conversion kits must be certified by the California Air Resources Board, which requires emission warranties equivalent to those provided by Original Equipment Manufacturers. Both the Air Resources Board and the California Bureau of Automotive Repair maintain lists of certified conversion kits and companies that do conversion work.

How much does it cost to retrofit a vehicle to use CNG? The cost to have a vehicle converted is between $1,500 to $4,000. Some disadvantages are that emissions may not be as low and there may be a slight power loss because the engine wasn't originally designed to run on CNG.

Are the vehicles covered by factory warranties? All vehicles produced by an Original Equipment Manufacturer (OEM) to run on natural gas have a full coverage warranty, same as a gasoline-powered vehicle. Vehicles that are converted after market to use CNG, may or may not be covered by the OEM warranty. The California Air Resources Board, however, requires that the retrofit component manufacturers fully warrant their products. A consumer should check with their vehicle's manufacturer about warranties before converting.

Are repair and maintenance costs for NGVs any different than gasoline vehicles? Although it is too soon to tell for sure, some reports indicate that maintenance will be considerably less frequent because of the cleanliness of the fuel, causing the engine to remain more reliable and efficient.

Is a special oil needed for the vehicle? No. The same oil used in a gasoline-only car can be used in an NGV.

Are NGVs safe in regards to accidents, leaks, etc.? According to American Gas Association, NGVs are safe because the cylinders that contain the CNG are built to much more rigorous standards than gasoline tanks. A detailed 430 million mile study on NGVs reported only one minor injury and no fatalities associated with the fueling system. The cylinders and high pressure fuel line have under gone stringent tests, including dropping from heights, explosions, being shot at with high-powered weapons, and burning in bonfires. The cylinders have passed these test with few if any problems.

Didn't some cylinders rupture? Yes, cylinders on two General Motors pickup trucks ruptured in early 1994, one in San Francisco and one in Minneapolis. The ruptures, however, were caused by model-specific installation design flaws that resulted in a weakening of the fiberglass wrap around the cylinders. GM recalled all the pickup trucks that were made with that cylinder design and reimbursed all buyers. After

rigorous reviews of their own cylinder installation designs, other OEMs declared their vehicles safe and continued productions immediately.

How do NGVs' exhaust emissions compare to that of a gasoline vehicle? When compared to gasoline, a dedicated natural gas vehicle, on average, emits 60 to 80 percent less carbon monoxide, up to 50 percent less nitrogen oxides, and ozone reactivity is decreased by up to 90 percent when compared to gasoline. California's first certified LEVs and ULEVs were both NGVs from Chrysler.

Are there incentives for purchasing natural gas vehicles? Yes. Incentives are being offered by the state's natural gas utility companies to convert a vehicle to run on natural gas or for the additional cost of an Original Equipment Manufacturer (OEM) NGV. The incentive typically runs about $1,250 per vehicle to a maximum of 50 percent of the conversion/extra cost.

The California Energy Commission also offers incentives toward natural gas vehicles. Additionally, the State of California offers a $1,000 tax credit on vehicles that are certified as low emission by the California Air Resources Board and $1,500 on vehicles certified as ULEV. The tax credit for California is based on the differential cost of equipping the vehicle to use the clean fuel — the amount above the price of a regular gasoline-only model. The Commission will probably offer incentives for ULEVs in 1995.

The federal government also offers a tax credit up to a maximum of $2,000 for clean-fuel vehicles that use alternative fuels such as ethanol, methanol, propane or natural gas.

Questions About Natural Gas

What is Compressed Natural Gas? CNG is a highly compressed form of the same fuel used in our households for cooking and heating. It is a combustible, gaseous mixture of simple hydrocarbon compounds, usually found in deep underground reservoirs formed by porous rock. Natural gas is a fossil fuel and can be found by itself or in association with crude oil or hydrocarbon condensates — gases that liquefy at normal atmospheric pressures and closely resemble mineral spirits. Natural gas is primarily composed of methane (CH_4), with minor amounts of ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}) and pentane (C_5H_{12}).

Natural gas has an ignition temperature of about 1,200 degrees Fahrenheit, about 600 degrees higher than gasoline. The heating value of natural gas depends on the proportion of gases making up the mixture. Most commercial natural gas has a heating value from 960 to 1,120 British thermal units (Btu) per cubic foot, with a rough average of 1,025 Btu/cubic foot or 102,500 Btu per therm.

Natural gas has been used for many years in stationary internal combustion engines with extremely high efficiency and reliability, but it hasn't been until recently that auto companies have began offering factory-produced NGVs.

How is natural gas produced?

Natural gas is exactly what it says — natural. Natural gas is a fossil fuel that is found in reservoirs 3,000 to 15,000 feet below the surface. In California, the typical natural gas-producing reservoir is found at depths of 6,000 to 8,000 feet. Because of its low density, natural gas does not have to be pumped from the reservoir to the surface wellhead.

Natural gas is not a petroleum product and is abundantly available in North America. Because it is a fossil fuel, however, there is a finite supply on the planet – estimated at 120-years at current levels of consumption and with known reserves. Its use as a transportation fuel will lessen our dependence on petroleum products. California's extensive network of natural gas pipelines can deliver the fuel directly to many sites through environmentally safe infrastructure, where compressors can be simply installed where needed.

How does CNG's octane rating compare to gasoline and M85 ? Natural gas has an octane rating of 130 as compared to super unleaded gasoline with an octane rating of only 92 and regular unleaded with an octane rating of 87. M85, by comparison, has an octane rating of 102.

Is there an increase in performance with CNG? With a retrofitted or converted vehicle, there may be a 5-10 percent power loss, but with a dedicated NGV, the loss can be overcome and there may be up to a 10 percent increase in power because the vehicle's compression ratio is changed to take advantage of the higher octane rating.

Is CNG more toxic or dangerous than gasoline? The California Natural Gas Vehicle Coalition says that natural gas is identified as non-toxic.

Is there a fire hazard associated with CNG? Natural gas is lighter than air. Because of this, if natural gas

were to be released or accidentally leaked, it would rapidly disperse. In addition to this, before the gas can actually ignite, it would have to mix with 6 to 16 percent air, which is unlikely unless designed to do so under specific conditions.

What is the difference between CNG and propane (liquefied petroleum gas or LPG)? Propane is a fossil fuel bi-product of natural gas processing and petroleum refining that is in a gaseous form at normal pressures and liquefies at relatively low pressure. LPG typically is made up of propane and butanes. It also has a lower octane, a lower energy content and is more volatile than natural gas. LPG is also heavier than air and will sink to the ground and "pool." Natural gas is lighter than air and dissipates readily.

What is the difference between CNG and LNG (liquefied natural gas)? LNG is natural gas that has been liquefied for easy storage or transport. Natural gas is turned into a liquid by extreme cooling to minus 327.2 degrees Fahrenheit. LNG is almost pure methane, and because it is a liquid, has an energy storage density much closer to gasoline than CNG. The requirements of keeping the liquid very cold, however, and its volatility make its applications more limited for transportation purposes. Some demonstrations are currently being undertaken to look at LNG for heavy-duty applications such as transit buses, heavy-duty long-haul trucks or locomotives.

What is the price of CNG? Fuel for NGVs costs about $0.70 to $1.00 when compared to its equivalent of one gallon of gasoline. This price varies according to local natural gas utility service area. The prices charged by natural gas utility companies for natural gas are approved by the California Public Utilities Commission. Non-utilities sell CNG at market prices. CNG and other alternative fuels (electricity and propane), however, are not yet fully taxed at gasoline-equivalent rates. In California, methanol and ethanol are taxed based on energy content compared to gasoline.

Questions and Answers About California's Natural Gas Supplies

Where does California get its natural gas? California gets its natural gas from both in and out of the state sources. Out of state sources, however, still remain in North America. According to the Energy Commission's *1991 Fuels Report*, in 1991, 57 percent of California's natural gas came from the U.S. Southwest, 21 percent from Canada, 19 percent from within state, and 3 percent from the Rocky Mountain area. In the year 2011, this is projected to change to 43 percent Southwest, 29 percent Canada, 18 percent from Rocky Mountain area, and 10 percent within state.

The American Gas Association estimated that if 1.7 million vehicles in the United States ran on natural gas, the supply needed would equal just 0.9 percent of the amount of natural gas produced in North America in 1988. The Energy Commission forecasts that in 2013, NGVs in California will use just under seven perecnt of the state's total amount of natural gas consumed (484 million cubic feet per day).

How does natural gas get to the consumer? California is criss-crossed with tens-of-thousands of miles of natural gas pipelines. Natural gas comes into the state from large diameter pipelines that normally operate at 250- to 1,000 pounds per square inch gauge (psig) pressure. Transmission lines transfer natural gas from a gathering line (production intertie) or storage facility to a distribution center or another storage facility. From there, natural gas is distributed to customers through either a 60-psig high-pressure distribution system or a low-pressure system that delivers natural gas to a residential gas meter at 1/4 psig. For refueling NGVs, the gas must be pressurized to 3,000 to 3,600 psig to fill the vehicle's cylinders. Typical CNG delivery pressure in California is 3,200 psig.

Who sells compressed natural gas? CNG is sold by natural gas utility companies and through a limited number of major gasoline retailers. Independent CNG retailers have also entered the market. In California, the utilities are City of Long Beach Gas Department, Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Gas Company. Shell, Unocal, Chevron and Texaco also sell CNG, as do FleetStar and MESA at a growing number of outlets.

Where can CNG be purchased? By December 1994, 124 NGV fueling stations were in existence throughout California (see map in Chapter 10). Of these stations, 78 have full or limited access to the public and 46 are private. Some of the public facilities are at regular gasoline service stations through contracts the natural gas utility companies have with Chevron, Shell, Texaco and Unocal. A total of 53 more fueling facilities (31 public/limited access and 22 private) are expected to open in 1995.

What is the cost of installing CNG refueling equipment? Can the equipment be installed for a public or private fleet? What about refueling at home? For a small private or public fleet of about ten vehicles, installation of fast-fill compressor facilities can cost between $180,000 to $250,000. A public access facility can cost up to $500,000. Quick-fill facilities for larger numbers of vehicles, such as a transit company, can be more expensive — as much as $3.5 million for the Sacramento Regional Transit District's natural gas bus refueling facility. Small, slow-fill refueling units can also be installed in a home for about $3,500, which will refuel a single vehicle overnight. Prices on these type of compressors are expected to drop and may, in the future, even be rented to residential customers who use NGVs.

How are the current fueling systems accessed? All public access facilities are accessed through a fuel card known as the Tech 21. This card is available through the local natural gas utility company.

NGV Model History

Chrysler's Dodge full-size *B-350 RAM Van*, powered by CNG, was the first vehicle to be certified as a Low Emission Vehicle by the California Air Resources Board. The van is being offered for sale in California and other states and are especially popular as van pool vehicles. In February 1993, Chrysler officials, along with the Southern California Gas Company and the Gas Research Institute, announced that Chrysler would sell a dedicated CNG minivan by January 1994. The Gas Company and GRI are helping pay for the development costs of the minivan. In January 1994, the California Air Resources Board announced that the Chrysler/Dodge Natural Gas-powered *Minivan* was the first vehicle to be certified as an Ultra-Low Emission Vehicle. The auto company also announced that both the full-size van and the minivan were available for sale to fleets and the public in 1995 and beyond. Chrysler officials say they can build up to 2,000 or more of each model per year. In the 1995 model year Chrysler will offer a Dodge *Dakota* Pickup and the Dodge *RAM Pickup* as NGVs.

In 1992 and 1993, Ford produced a limited number of Crown Victoria sedans and other vehicles powered by natural gas. These demonstration vehicles were distributed to natural gas utility companies for testing and evaluation purposes. In early 1994, Ford announced its intentions to produce natural gas F-series pickup trucks, full-size vans and *Crown Victoria* sedans for sale to fleets and the general public. The company also offers its medium-duty F700 series engines with configurations to run on natural gas or propane.

General Motors produced 2,500 GMC *Sierra* and Chevrolet 1992 and 1993 model year 3/4-ton pickup trucks to run on natural gas. In the 1994 model year, GM had planned to offer a full line up of bi-fuel natural gas vehicles. These vehicles could switch from natural gas to gasoline when on-board supplies of natural gas were too low. Bi-fuel models that were to be offered included a Chevrolet *Corsica* and *Caprice*, 1/2- and 3/4-ton pickup trucks, a full-sized van, and various configurations of other specialty vehicles. In early 1994, however, two cylinders mounted on GMC pickup trucks ruptured. One instance occurred in San Francisco and the other in Minneapolis. This prompted GM to recall its 2,500 1992–1993 GMC *Sierra* and Chevrolet NGV pickup trucks. The company also announced it was suspending all sales of its bi-fuel vehicles for the 1994–95 model year.

Foreign automobile companies are also interested in the use of natural gas in their vehicles. In January 1994, Honda unveiled an *Accord* model dedicated natural gas vehicle at the Greater Los Angeles Auto Show. The company said it plans to offer the vehicle sometime in the future, but would make no statements about its marketing strategy. Honda is currently testing CNG-powered *Civics* in utility company fleets. Other manufacturers are noncommittal about plans for NGV sales in California.

NGVs Being Used/Sold

Are NGVs really an "advanced technology" of the future? The list on the next page, compiled in September 1994 by the National Natural Gas Vehicle Coalition from a survey of manufacturers, illustrates that commercialization for every major on-road and off-road vehicle category is well under way today. The status of vehicles indicated below is for the 1995 model year, as well as projected by the manufacturers.

According to the California Natural Gas Vehicle Coalition, "Each of the companies has made a substantial commitment to providing California and the nation with a clean, cost-effective option to conventionally-fueled vehicles in the very near future. This aggregate commitment, along with that of the natural gas industry to rapidly expand fuel infrastructure, shows clearly that NGVs are poised to win a significant share of the 21st century transportation market, particularly if our regulatory policies continue to place a high value on healthful air and water, and a healthy domestic economy."

Recent Natural Gas Light-Duty Vehicles

Manufacturer	Model	Status
Passenger Cars		
Ford	Crown Victoria	Demo (1996 production)
GM	Chevrolet Caprice	Prototype
	Chevrolet Corsica	Prototype
Honda	Civic	Demo
Vans		
Chrysler	Dodge B250 RAM Van	Available (LEV certified)
	Dodge B350 RAM Van	Available (LEV certified)
	Dodge Caravan	Available (ULEV certified)
	Plymouth Voyager	Available (ULEV certified)
Ford	Econoline 250	OEM approved conversion
	Econoline 350	OEM approved conversion
Pickups		
Chrysler	Dodge RAM Pickup	Available (certification pending)
	Dodge Dakota Pickup	Available (certification pending)
Ford	Ford F-150 Pickup	OEM approved conversion
	Ford F-250 Pickup	OEM approved conversion
GM	GMC Sierra Pickup	Prototype
	Chevrolet Pickup	Prototype

Because heavy-duty engines can be adapted into many truck body styles and types, and used for many uses, please also see listings in Chapter 8 on Heavy-Duty Vehicles/Engines.

Current CARB-Certified Light-Duty NGVs

(As of November 11, 1994)

1994 Chrysler B250 Van and Wagon (LEV)

1994 Chrysler B350 Van and Wagon (LEV)

1994 Dodge Caravan/Plymouth Voyager Minivan (ULEV)

1994 Ford Crown Victoria NGV (LEV)

1994 Ford Econoline Full-size Van (LEV)

1994 Ford F-150 Pickup Truck (LEV)

1995 Chrysler Dodge Caravan/Plymouth Voyager Minivan (ULEV)

1995 Dodge RAM Pickup (certification pending)

1995 Dodge Dakota Pickup (certification pending)

NGV Contacts

Auto Makers

A. Michael Clement
Alternative Fuels Vehicle Marketing
Chrysler Corporation
12000 Chrysler Drive
CIMS 414-03-44
Highland Park, MI 48288
313-956-4599

Michael Coates
Western News Bureau
Chrysler Corporation
601 West 5th Street, 4th Floor
Los Angeles, CA 90071
213-622-1644

Lou Ulrich
Account Executive
Fleet Sales Dept.
General Fleet Office
Ford Division
2099 South State College Blvd.
Suite 600
Anaheim, CA 92816
714-939-3562

W.J. "Bill" Boultes
Account Executive
Fleet Sales Dept.
General Fleet Office
Ford Division
P.O. Box 9048
Pleasanton, CA 94566
510-463-5791

Ford Motor Company
Alternative Fuel Vehicle Hotline
1-800-ALT-FUEL (258-3835)

Gerald J. Barnes
Manager
Automotive Emissions Contrail
General Motors Corporation
3044 West Grand Blvd.
Detroit, MI 48202
313-556-7723

California Fuel Providers

City of Coalinga Gas Service
160 West Elm Street
Coalinga, CA 93210
209-935-1531

Dale Holdman
City of Long Beach Gas Department
2400 East Spring Street
Long Beach, CA 90806
310-570-2052

Michael Boucher
Manager, Western Region
FleetStor Inc.
25251 Paseo de Alicia, Suite 200
Laguna Hills, CA 92653
714-72-9599

Joe Garcia
Corporate Representative
Clean Air Vehicles
Market Development
Pacific Gas and Electric Company
123 Mission Street, Room H-2537
P.O. Box 770000
San Francisco, CA 94177
415-973-2072

Cheryl Popp
Corporate Communications
Pacific Gas and Electric Company
Moil Code B29E
P.O. Box 770000
San Francisco, CA 94177
415-972-5206

Bill Sessa
News Services Bureau Chief
Pacific Gas and Electric Company
925 L Street, Suite 890
Sacramento, CA 95814
916-446-6616

Andrew Littlefair
Vice President, Public Affairs
MESA
2600m Trammell Crow Center
2001 Ross Avenue
Dallas, TX 75201
214-969-2208

Joe Semerad
Natural Gas Vehicle Marketing
San Diego Gas & Electric
8306 Century Park Court, Suite 4200
San Diego, CA 92123
619-654-1108

Stephanie Donovan
Media & Public Relations
Alternative Fuel Vehicles
San Diego Gas & Electric
8306 Century Park Court
San Diego, CA 92123
619-696-4285

Michael R. Morelli
Natural Gas Vehicle Service Manager
Southern California Gas Company
P.O. Box 3249, ML 25DO
Los Angeles, CA 90051-1249
800-GAS-2000

Denise King
News Bureau
Southern California Gas Company
555 West 5th Street
Los Angeles, CA 90017
213-244-2548

Ken Olsen
Manager of Research
Southern California Gas Company
ML 19EO
P.O. Box 3249
Los Angeles, CA 90051
213-244-5350

Southwest Gas Corporation
P.O. Box 15015
Las Vegas, NV 89114
702-876-7011

Conversion Kit Companies

(Note: Check with California Air Resources Board for latest list of approved conversion kits.)

Algas Carburetion
16101 Vallen Drive
Houston, TX 77041

Automotive Natural Gas Inc.
265 North Janesville St.
Milton, WI 53563
608-868-4626

Beam Products Manufacturing Company
3040 Rosslyn Street
Los Angeles, CA 90065

Beacon Power Systems
447 E. Elmwood
Troy, MI 48083

Carburetion Labs
515 N.E. 190 Street
Miami, FL 33179

Century Products
(Formerly Vialle Autogas Systemen)
9101 Ely Road
Pensacola, FL 32514

Challenger Energy Products
702 W. 48th Ave.
Denver, CO 80216

Clean Fuels
3125 W. Bolt
Ft. Worth, TX 76110

College of the Desert
Energy technology Training Center
Attn: Colin Messer
43500 Monterey Ave.
Palm Desert, CA 92260
619-773-2545
(student training classes in NGVs)

Dual Fuel Systems Inc.
Subsidiary of Pacific Lighting Corp.
1120 Maple
Montebello, CA 90640

Essex Cryogenics
8007 Chivvis Drive
St. Louis, MO 63123

Impco Carburetion Inc.
16916 Gridley Pl.
Cerritos, CA 90701
213-860-6666

Mesa Environmental
3125 West Bolt Street
Fort Worth, TX 76110

Metropane Inc.
2772 Sawbury Rd.
Columbus, OH 43235

Mogas Sales
4467 Juneao St.
Burnaby, B.C.
CANADA V5C 4C4

Natural Fuels Corp.
5865 Stapletan Dr., N.
Denver, CO 80216

NGV Development
2250 Cherry Industrial Circle
Long Beach, CA 90805

PAS Inc.
570 Executive Dr.
Troy, MI 48083

Stewart & Stevenson
5840 Dahlia St.
Commerce City, CO 80022

Tren Fuels
701 Brazos #520
Austin, TX 78701

Vialle U.S.A. Inc.
(Formerly Vialle Autogas Systemen)
9101 Ely Rd.
Pensacola, FL 32514

Home Compressor Equipment

Fuelmaker Inc.
P.O. Box 11865
Salt Lake City, UT 84147
801-530-2859

RIX Industries
6460 Hollis St.
Oakland, CA 94608
510-658-5275

Government

California Energy Commission
Transportation Technology & Fuels Office
1516 Ninth Street, MS-41
Sacramento, CA 95814
916-654-4634

Ruth Anne Keister
Manager
Clean Cities Hotline
P.O. Box 12316
Arlington, VA 22209
1-800-C-CITIES

L.R. Davis
Director of Maintenance
Metropolitan Transportation Authority
900 Lyon Street
Los Angeles, CA 90012
213-291-7625
Toras Topaloglu
Ministry of Transportation of Ontario
1201 Wilson Avenue
Downstream, Ontario
CANADA M3M 1J8
416-235-5017

Linda Bluestein
Contract Manager
National Alternative Fuels Hotline
P.O. Box 12316
Arlington, VA 22209
800-423-1DOE (1363)

National Appropriate Technology
Assistance Service (NATAS)
P.O. Box 2525
Butte, MT 59702
800-428-2525

Brent Bailey
National Renewable Energy
Laboratory
1617 Cole Blvd.
Golden, CO 80401
303-231-1288

Greg Dolan
New York State Energy Research &
Development Authority
Two Rockefeller Plaza
Albany, NY 12223
508-465-6251 ext 226

Texas General Land Office
1700 North Congress
Austin, TX 78701
800-638-3599

Richard Wares
Program Manager
Office of Alternative Fuels
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 25085
202-586-8031

John Mueller
National Vehicle
& Fuel Emissions Laboratary
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4275

Tad Wysor
Clean Fuel Fleets Program
U.S. Environmental Protection Agency
2656 Plymouth Road
Ann Arbor, MI 48105
313-668-4332

David Gushee
Senior Specialist, Environmental Policy
U.S. Library of Congress
Congressional Research Service
Washington, DC 20540
202-707-7228

Organizations

E. Eugene Ecklund
Executive Director
Alternative Transportation Fuels
Foundation
HCR-72, Box 547-8 LOW
Locust Grove, VA 22508
703-972-0484

Carol May
Manager, NGV Market Development
American Gas Association
1515 Wilson Blvd.
Arlington, VA 22209
703-841-8574

Peter Baljet
Chairman
American Lung Association
National Air Conservation Commission
9350 South Dixie Highway,
Suite 1540
Miami, FL 33153
305-670-6774

Robert Cumming
Canadian Gas Association
950 Burnhamthorpe Road W.
Mississauga, Ontario
CANADA L5C 3B4
416-897-1690

Edward Farkas
Senior Engineer
Canadian Gas Research Institute
55 Scarsdale Road
Don Mills, Ontario
CANADA M3B 2R3
416-447-6465

Wayne Parker
General Manager
Clean Air Vehicle Association
14 Piedmont Center, Suite 1205
Atlanta, GA 30305
404-237-1980

Ginny Hobbs-Moore
CNG & LNG Research Programs
Gas Research Institute
8600 Bryn Mawr Avenue
Chicago, IL 60631
312-399-8100

Norm Yale
Project Manager
Gas Research Institute
8600 W. Bryn Mawr Avenue
Chicago, IL 60631
312-399-5414

William Vavrik
Institute of Gas Technology
3424 S. State Street
Chicago, IL 60616
312-567-3877

David P. Lefever
Executive Director
National Assn. of Fleet Administrators
120 Wood Avenue South, Suite 615
Islelin, NJ 08830
908-494-8100

Ted Lemoss
(NGV & Fire Code Research)
National Fire Prevention Association
One Batterymorch Park
P.O. Box 9101
Quincy, MA 02269
617-984-7407

Michael McGuire
Executive Director
Natural Gas Vehicle Coalition
1515 Wilson Blvd.
Arlington, VA 22209
703-527-3022

Gregory Vlosek
Executive Director
Natural Gas Vehicle Coalition
925 L Street, Suite 1485
Sacramento, CA 95814
916-448-5036

L. Donald Shields
Coordinator
Project California
California Council
on Science & Technology
100 Academy Drive
Irvine, CA 92715
714-854-4150

Dovid DuBois
Society of Automative Engineers
(SAE)
400 Commonwealth Drive
Worrendale, PA 15095
412-772-7159

Chapter 7

Propane / LPG-Powered Vehicles

Overview

More than 350,000 vehicles, mostly in fleets, are traveling the nation's highways under propane power. Also known as LPG (or liquefied petroleum gas, a category that also includes butane and ethane), propane is powering taxis in Las Vegas; school buses in Kansas City and Portland, Oregon; and sheriff and police cars in other communities. Propane is used in both light- and medium-duty vehicles. Estimates have placed the number of registered vehicles in California that are powered by propane as high as 40,000. Propane has been used as a transportation fuel for more than 60 years.

Propane is a gas in its natural state. It turns to liquid under moderate pressure and is stored in vehicle fuels tanks as such. When liquid propane is drawn from the tank, it is changed back to a gas before it is burned in the engine. Propane is a by-product of petroleum refining and from natural gas production. In California, propane is mostly produced from the petroleum refining process. Because of this, the fuel is considered by California a "clean" fuel but not regarded as an "alternative" fuel because of its direct links to petroleum production. The federal government, however, lists propane as an alternative fuel.

Propane is a clean fuel which offers a range closest to gasoline. One gallon of propane contains less energy than a gallon of gasoline (82,485 Btu for propane versus 115,400 Btu for gasoline), but propane companies say the miles per gallon should be about equal if the vehicle is tuned properly. Compared to gasoline, propane vehicles emit about one-third less reactive organic gases, reduce nitrogen oxides by about 20 percent, and show a reduction of about 60 percent in carbon monoxide.

Propane is widely available in urban areas or tanks can be installed on-site for fleet use. It can also be found in rural areas, where propane is used for heating and cooking when natural gas is not available, and at service stations that refuel recreational vehicles' propane tanks.

Converting an automobile or light-duty truck from gasoline to propane costs about $1,000 - $2,000 and can usually be done in one day. Conversions must comply with safety standards set by the National Fire Protection Association, and kits must be certified by the California Air Resources Board. (Contact CARB for its latest list of certified equipment and installers.) Modifications typically include: a heavy steel or high-strength fuel tank added to the trunk or truck bed, fuel lock filter/shut-off valve, vaporizer/regulator, and air/fuel mixer. Conversion kit parts are reusable. Dual-fuel gasoline/propane systems are also currently available.

Early problems with propane-powered vehicles included blown head gaskets and cylinder problems, apparently due to the drying effect of the gas and lack of lubricating agents. Those early problems have apparently been solved. Another drawback commonly cited about propane vehicles is the loss of trunk space in dual-fuel passenger vehicles due to installation of the tank, which is about the size of a spare tire or larger.

On the positive side, propane-powered vehicles have less carbon build-up compared to gasoline- and diesel-powered vehicles. According to the National Propane Gas Association, spark plugs from a propane vehicle last from 80,000 to 100,000 miles and propane engines can last two to three times longer than gasoline or diesel engines.

Propane retail prices were, on average, about the same as unleaded gasoline prices during the late 1980s and 1990s. Propane prices, however, can fluctuate widely and are often tied to oil prices. Shortages of propane, such as the shortage in New England during a cold wave a number of years ago, can also increase propane prices quickly.

The Energy Commission is involved in a side-by-side comparison of 113 fleet delivery vehicles in Southern California. Propane is one of the five fuels being studied in the $11 million CleanFleet program. Federal Express is the fleet operator, and Battelle Memorial Institute is the technical contractor. The two-year test program concluded in October 1994.

Current Vehicles Offered For Sale

Some auto manufacturers are considering offering a propane option (in passenger cars, vans and pickup trucks) in their model line-up or offering engines that have been optimized for gaseous fuels. It would then be up to the purchaser to have the vehicle converted to propane with third-party equipment. Ford is selling its *F-700* series medium-duty truck with a California Air Resources Board-certified propane engine option. Chevrolet offers its 5.7 liter V-8 pickup truck/van engine with a propane option.

For more information about propane in California, contact:

Western Liquid Gas Association ..... (916) 485-4382

LPG Clean Air Coalition ..... (714) 253-5727

For the latest list of Approved Alternative Fuel Conversion Systems, contact the California Air Resources Board Certification Branch at (818) 575-6800, or call CARB Public Information toll-free at (800) 242-4450.

LPG / Propane Contact List

Conversion Equipment Companies

(Note: Check with Air Resources Board for latest list of Approved Conversion Systems.)

Advanced LP Systems Inc.
5327- Jocuzzi St.
Richmond, CA 94804

Algas Corporation
16101 Vallen Drive
Houston, TX 77041

Bean Products Manufacturing Company
3040 Rosslyn St.
Los Angeles, CA 90065

Carburetion Labs
515 N.E. 190 Street
Miami, FL 33179

Eagle Propane
1871 Lake Place
Ontario, CA 91761

Greenway Environmental Research
40208 Industrial Park Circle
Georgetown, TX 78626

Halley Replacement Parts Division
Calt Industries Operating Corp.
11955 East Nine Mile Rd.
Warren, MI 48090

Impco Carburetion Inc.
16916 Gridley Pl.
Cerritas, CA 90701
213-860-6666

Landi-Hartzog, U.S. Inc.
3208 South Hutchison Ave.
Los Angeles, CA 90034

LFF Carburetion Inc.
P.O. Box 522
Hutchison, KA 67501

Marvel Schleber/Tillotson
Division of Borg Warner Corp.
2195 South Elwin Rd.
Decatur, IL 62625

OHG Inc.
10065A Greenleaf Ave.
Santa Fe Springs, CA 90670

Toyo Red Cab LPG Conversion
16609 South Halldale Ave.
Gardena, CA 90247

Vialle U.S.A. Inc.
(Formerly Vialle Autogas Systemen)
9101 Ely Rd.
Pensacola, FL 32514

Government

California Energy Commission
Transportation Technology and Fuels Office
1516 Ninth Street, MS-41
Sacramento, CA 95814
916-654-4634

John Mueller
National Vehicle
& Fuel Emissions Laboratory
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4275

Organizations

Bob Myers
Executive Director
LPG Clean Fuels Coalition
2102 Business Center Dr., Suite 130
Irvine, CA 92714
714-2543-5757

Rita Pecilunas
Director of Marketing
National Propane Gas Association
1600 Eisenhower Lane
Lisle, IL 60532
708-515-0600

Lisa Bontempa
Government Relations
National Propane Gas Association
4301 Fairfax Drive, Suite 340
Arlington, VA 22203
703-351-7500

Rick Roldan
Executive Director
Propane Vehicle Council
901 15th St., N.W., Suite 700
Washington, DC 20005
202-371-6262

Ron Myron
Western Liquid Gas Association
7844 Madison Ave., Suite 150
Fair Oaks, CA 95628
916-962-2280

Chapter 8

Alternative Fuel Heavy-Duty Vehicles & Engines

Since October 1989, the California Energy Commission has tested the use of alternative fuels in heavy-duty engines and vehicles. Initially, methanol was tested, but in mid-1992, compressed natural gas heavy-duty engines were added to the program. The Energy Commission has also worked with various bus manufacturing companies to put alternatively fueled transit and school buses on the road.

The demonstration program tests the feasibility of using cleaner-burning fuels in heavy-duty trucks and buses to diversify California's transportation fuels and to help improve California's air quality. The Commission has studied alternative transportation fuels since 1978. A number of fuels have been successful in establishing competition with conventional fuels and engine designs to achieve long-range goals for California.

Heavy-Duty Truck Program

The Commission and the South Coast Air Quality Management District (SCAQMD) initially brought together engine manufacturers with host demonstration sites in unique public/private partnerships with methanol. Air Products provided additional support for methanol.

Southern California Gas Company, the Department of Energy's National Renewable Energy Laboratory and the American Trucking Association Foundation have joined the program in sponsorship of compressed natural gas. The engine manufacturers provide new engines designed to run on alternative fuels. The host sites provide vehicles for the new alternative fuel engines, as well as operation, maintenance and fuel. The sponsors cost-share engine technology, provide technical support, and compile and analyze data on the test vehicles.

Participating in the program are five engine manufacturers (Detroit Diesel Corporation [DDC], Caterpillar, Cummins, Ford and Navistar) and 12 host sites (Arrowhead Drinking Water Company; Cities of Glendale, Los Angeles, and South Lake Tahoe; the County of Sacramento and the Los Angeles County Sanitation Districts; Federal Express and Golden State Foods with Penske Truck Leasing; Waste Management Inc.; the Vons Companies Incorporated; the Los Angeles Times/Times Mirror Corporation; and the Port of Long Beach).

Why the Focus on Methanol and Natural Gas?

Methanol and compressed natural gas provide two benefit s over diesel: energy diversity and air quality. Methanol is a clean-burning liquid fuel that can be made from natural gas, coal or biomass. Natural gas is a clean-burning and widely available gaseous fuel that can be compressed for use by heavy-duty vehicles.

Using these domestic resources can decrease dependence on petroleum. The two fuels are the closest major competitors (in terms of technology and availability) to diesel.

Methanol trucks in the Heavy-Duty Demonstration Program use M100 (100 percent methanol) or M85 (85 percent methanol and 15 percent unleaded gasoline) dispensed from private fuel stations and a network of more than 50 public stations.

Natural gas trucks in the Demonstration Program use pipeline natural gas compressed at a network of more than 100 public and private fueling facilities sponsored by gas utilities. The L.A. County Sanitation Districts will be using "cleaned" landfill gas (called CLG and made up of mostly methane) in their truck. Other natural gas trucks with similar engines will use LNG (liquefied natural gas), a cryogenic liquid that may allow trucks to achieve ranges found on conventional diesel trucks.

Heavy-duty trucks and buses are now required to meet strict 1994 state and federal clean air standards. Current methanol and natural gas heavy-duty engine technology can meet the much tougher emission standards established or planned for 1998 and beyond. Methanol and natural gas trucks reduce visible smoke, nitrogen oxides and particulate emissions – all of which represent public health hazards and contribute to poor air quality.

In August 1991, the U.S. Environmental Protection Agency and the California Air Resources Board certified Detroit Diesel's 6V-92 methanol engine as the first heavy-duty production engine to meet the tougher standards. The Los Angeles County Metropolitan Transportation Authority (MTA, formerly Southern California Rapid Transit District) has 339 methanol transit buses currently serving Los Angeles with DDC methanol engines.

In 1993, the Cummins L10-240G was certified by EPA and CARB to achieve similar low emission levels on compressed natural gas. The Sacramento Regional Transit District has 95 transit busescurrently serving Sacramento with Cummins natural gas engines. Other transit districts have added CNG-powered buses to their fleets.

Safe School Bus Clean Fuel Efficiency Demonstration Program

Legislation signed into law in 1988 by Governor George Deukmejian and authored by Assemblyman Richard Katz (AB 35) appropriated $60 million for the Safe School Bus Clean Fuel Efficiency Demonstration Program. Funding comes from the Petroleum Violation Escrow Account (PVEA). These funds, collected and dispersed by the federal government, are fines paid by oil companies that overcharged consumers in the 1970s. The $60 million was augmented by another $40 million in additional PVEA appropriations, bringing the total program to $100 million.

The initial $60 million was used to purchase buses in two phases — $20 million to purchase 163 buses in Phase 1 and $40 million to purchase 400 buses in Phase 2. Additional buses will be purchased in Phase 3 with the additional PVEA appropriations. Program Opportunity Notices for this third phase were sent out to California school districts in mid-1994 with selection of districts and bus manufacturers expected in 1995.

The overall objectives of this program are: to demonstrate direct energy savings without causing adverse air quality impacts, reduce tax dollars wasted in vehicles that are not fuel efficient, and promote use of state-of-the-art safety features in school buses.

This project allows school districts to upgrade their fleets in a cost-effective manner and replace buses that were built prior to the 1977 Federal Motor Vehicle Safety Standards. The older buses being replaced will not be allowed to transport school children or workers

Who Funds the Heavy-Duty Demo Programs?

	Methanol	Natural Gas	Total
Energy Commission	$1,425,243	$243,000	$1,668,243
SCAQMD	$1,450,336	$475,000	$1,925.336
SoCal Gas	---	$496,000	$496,000
DOE/NREL/ATAF *	---	$464,000	$464,000
Air Products Company	$176,418	---	$176,418
Total	$3,051,997	$1,678,600	$4,730,597

* Department of Energy, National Renewable Energy Laboratory, American Trucking Association Foundation

Alternative Fuel Heavy-Duty Truck Demonstration Program (As of Dec. 1994)

ORGANIZATION	*TYPE*	*ENGINE*	*HP*	*CHASSIS*	*FUEL*
City of Los Angeles	Dump truck	Cummins L10	270	Peterbilt 379	M95 +A*
City of Los Angeles	Sludge hauler	DDC 6V-92TA	350	GMC-General	M100
City of Glendale	Refuse hauler	Cat. 3306 DITA	245	Peterbilt 320	M100
Golden State Foods	Tractor/trailer	DDC 6V-92TA	300	Freightliner	M100
Federal Express	Tractor/trailer	DDC 6L-71TA	300	Freightliner	M100
Arrowhead Water	Delivery truck	Ford 6.6L MX	170	Ford F800	M85
City of South Lake Tahoe	Dump truck/sander	Navistar DT-466	210	International 4800	M100/85
County of Sacramento	Flatbed truck	Navistar DT-466	210	International 4900	M100/85
Waste Management Co.	Refuse haulers (2)	DDC 6L-71TA	240	Volvo/White	M100
Port of Long Beach	Cargo Hostlers (2)	DDC 4L-71TA	200	Ottawa	M98 + A**
The Vons Companies Inc.	Tractor/trailer	Cat. G3406 Mobile	350	Ford LTLA-9000	CNG
The Los Angeles Times	Tractor/trailer	DDC Series 60G	370	Ford LTLA-9000	CNG
LA County Sanitation Dist.	Tractor/trailer	DDC Series 60G	370	Freightliner	CLG

* 95% Methanol plus 5% Avocet ignition improver. ** 98% Methanol plus 2% Avocet ignition improver.

within California. Most of them will either be "parted out" or scrapped.

To help achieve the objectives of the program, at least 35 percent of the replacement school buses have to be powered by low-emission, clean-burning fuels such as methanol (methyl alcohol) or compressed natural gas.

Criteria for Evaluation

Local educational agencies of all sizes, geographic areas and climate zones were considered as potential sites and candidates for the first two phases of this demonstration program. Energy Commission staff evaluated scores of proposals that were submitted for funding under both phases. Criteria for the final selection of districts and consortiums included:

- Local school district fleet composition based on percent of vehicles built prior to the 1977 Federal Motor Vehicle Safety Standards, the age of the buses targeted, total number of miles on targeted buses, miles driven during the school year, and fuel consumption of buses being replaced.
- Local school district capabilities to meet program requirements such as maintenance and fueling capabilities, resource contributions, cooperation and enthusiasm of local districts to the program, and contingency plans.
- Environmental considerations such as local air quality levels, including whether the district was in an air pollution non-attainment area, petroleum savings and geographic location.

A Signal to School Bus Manufacturers

The Energy Commission's program has sent a signal to school bus manufacturers that California school districts will require advanced safety features, and high-efficiency and alternatively-fueled buses, both now and in the future. California's leadership role will influence the school buses being built and used around the country.

In the first phase of the program, the 163 buses were built by Crown Coach Bus Company and Blue Bird Body Company and distributed to 14 school districts and consortiums. Crown Coach, formerly of Chino, California, built 103 advanced, high-efficiency diesel and 50 methanol-powered buses that used Detroit Diesel engines. Ten Blue Bird buses used General Motors chassis and were built by Blue Bird Body Company of Fort Valley, Georgia, and distributed by Golden State Bus Sales of West Sacramento, California. These ten buses are powered by GMC 427 cubic inch V-8 engines converted by Tecogen of Waltham, Massachusetts, and use compressed natural gas (CNG).

The Tecogen natural gas engine and Detroit Diesel's methanol engine were been certified by the U.S. Environmental Protection Agency and the California Air Resources Board as meeting the 1994 heavy-duty vehicle emission standards.

In Phase 2 of the program, a total of 400 school buses will be built and distributed to 47 school districts and consortiums. Of these, 200 are high-efficiency diesel, 100 methanol-powered and 100 fueled by natural gas. The 78-passenger advanced diesel buses are built by Thomas Bus Company and are powered by a Caterpillar CAT 3116TA engine, rated at 229 horsepower. The 78-passenger methanol-fueled buses are built by Carpenter using a Detroit Diesel Corporation DDC 6V-92TA engine, rated at 253 horsepower. The natural gas buses also will hold 78 students and are built by Blue Bird Bus Corporation using a Tecogen Tecodrive 7000 engine, rated at 222 horsepower.

Delivery of the Phase 2 buses began at the end of 1992 and was completed in the fall of 1993.

Phase 3 will expand the program based on findings from Phases 1 and 2. This phase is scheduled to begin in 1994 with solicitations to school districts. Buses would probably be delivered in 1995 and perhaps into 1996 in this third phase. A limited number of electric-powered school buses, built by original equipment manufacturers, may be added in the third phase.

Electric School Buses On the Road for Testing

Under a separate program, the Energy Commission and CALSTART, a consortium of companies and government entities working to develop advanced transportation technologies, are developing electric-powered school buses. A demonstration program under the Commission's Transportation Energy Technologies Advancement Program (TETAP) retrofit two 67-passenger, diesel-powered school buses to run on electricity and built one prototype electric school bus "from the ground up." The buses will be in service in the Goleta Union School District and the Santa Maria/Bonita School District, both in Santa Barbara County. The retrofit and prototype buses are being built by Bus Manufacturing USA Inc. of Santa Barbara, APS Systems of Oxnard and Specialty Vehicle Manufacturing Corporation of Downey. The cost of this demonstration project is $192,700 of Energy Commission funds and $823,000 of matching funds.

Other Buses

The Commission's programs to move the bus manufacturers to alternative fuels is apparently working. In late 1994, Blue Bird Body Company began selling the first Original Equipment Manufacturer school bus powered by natural gas. The bus company, based in Georgia, is also testing an electric-powered school bus in the Antelope Valley School District.

Additional Information on School Buses

For more information, please contact:

California Energy Commission
Transportation Technology & Fuels Office
Safe School Bus Clean Fuel Efficiency Demonstration Program
1516 Ninth Street, MS-41
Sacramento, CA 95814
(916) 654-4685

CARB-Certified Heavy-Duty Engines
(As of November 14, 1994)

Year	*Manufacturer*	*Engine Use*	*Model/Size*	*Fuel Type*
1991	Detroit Diesel	School Bus, H-D Truck	DDC 6V-92TA	M85/M100
1991	Tecogen	School Bus	Tecogen 7000/7.0 liter	CNG
1993	Cummins	Transit Bus	L10-240G/10.0 liter	CNG
1994	Cummins	Transit Bus	L10-240G/10.0 liter	LNG
1994	Detroit Diesel	Bus, H-D Truck	Series 50/8.5 liter	CNG
1994/95	Ford	M-D/H-D Truck	F700/7.0 liter	LPG
1994	Hercules	M-D Truck, Shuttle Bus	GTA35/3.5 liter	CNG
1994	Hercules	M-D/H-D Truck, Bus	GTA 56/5.6 liter	CNG

Other Heavy-Duty Engines Not Certified by CARB

Year	*Manufacturer*	*Engine Use*	*Model/Size*	*Fuel Type*
1990	Caterpillar	Demo	3306 DITA	M100
1990	Detroit Diesel	Demo	DDC 6L-71TA	M100
1991	Ford	Demo	Ford 6.6L MX	M85
1991	Navistar	Demo	DT-466	M85/M100
1992	Detroit Diesel	Prototype	6V92DI-NG	CNG
1992	Detroit Diesel	Prototype	6V92PI-NG	CNG
1993	Caterpillar	Demo	G3406 Mobile	CNG
1993	Detroit Diesel	Demo	Series 60G	CNG
1994	Caterpillar	Demo	G3306	CNG/LNG/LPG
1994	Caterpillar	Demo	G3406	CNG
1994	Caterpillar	Demo, marine use/boats	G3412	CNG/LNG
1994	Cummins	Bus, HD Truck Available	L10-260G	CNG
1994	Cummins	Demo	6B/5.9 Liter	CNG (LNG?)
1994	Cummins	Prototype	C8.3G	CNG/LNG
1994	Cummins	Prototype	M11-280-330G	CNG
1994	Cummins/SwRI *	Demo	NTC-400	CNG
1994	Detroit Diesel/Navistar	School Bus, MD Truck - Avail.	Series 30G/7.3 Liter	CNG
1994	Detroit Diesel	Demo	Series 60G	CNG
1994	John Deere	Demo	6081 HFN	CNG
1994	Mack/SwRI *	Prototype	E7	CNG
1994	Mercedes-Benz	Bus (Available in Brazil)	M 366 G, 5.96 Liter	CNG
1994	Navistar	HD Truck - Available	T444NG	CNG
1994	Tecogen	MD Truck - Available	TecoDrive 4.3 liter	CNG
1994	Volvo	Bus (Avail. in Europe)	Bases, 9.9 Liter	CNG

Note: * SwRI = Southwest Research Institute
M-D = medium-duty; H-D = heavy-duty;
M85 = 85% methanol, 15% gasoline; M100 = 100% methanol;
CNG = compressed natural gas; LNG = liquefied natural gas;
LPG = liquefied petroleum gas (propane).

Contacts for Heavy-Duty Alternative Fuel Engines and Vehicles

Engine/Vehicle Manufacturers

Geoffrey Ballard
Chairman
Ballard Power Systems
(Fuel Cells for Transit Buses)
107 - 980 West 1st Street
Vancouver, British Columbia
CANADA V7P 3N4
604-9B6-9367

John Riet
Project Manager,
Alternative Fuels Manager
Bus Industries of America
5395 Maingate Drive
Missassauga, Ontario
CANADA L4W 1G6
416-625-9510

Tom Williams
Engine Division
Caterpillar Inc.
P.O. Box 610
Mossville, IL 61552
309-578-3359

Clark Ahrens
Bus Engine Sales
Cummins Engine Company
1900 McKinley Avenue
Columbus, IN 47201
B12-377-733B

Vinnod Duggal
Director of Development, Alternative Fuels
Cummins Engine Company
1900 McKinley Avenue
Columbus, IN 47201
812-377-7338

Nancy Martin
Editor, Newsletter of Alternative Fuels
Detroit Diesel Corporation
13400 Outer Drive, West
Detroit, MI 48239
313-592-5153

Stan Miller
Manager, Alternate Fuel Project Centers
Detroit Diesel Corporation
13400 Outer Drive, West
Detroit, MI 48239
313-592-7046

Nick Vermet
Vice President, Bus and Coach Sales
Detroit Diesel Corporation
13400 Outer Drive, West
Detroit, MI 48239
313-592-5292

Carl Chorba
Regional Sales Manager,
Western Region
Ford Motor Company
Truck Operations
P.O. Box 9048
Pleasanton, CA 94566
510-942-8072

Kim Boyer
Hercules Engine Company
101 - 11th Street, S.E.
Canton, OH 44707
216-438-1361

Kevin Flaherty
Mack Trucks Inc.
2100 Mack Blvd., Box M
Allentown, PA 18105
215-439-3815

Daniel Ustin
Navistor International Corporation
455 N. Cityfront Drive
Chicago, IL 60611
70B-865-4304

Edward Doyle
Tecogen Inc.
45 First Ave.
Waltham, MA 02254

Government

California Energy Commission
Transportation Technology & Fuels Office
Heavy-Duty Demonstration Program
1516 Ninth Street, MS-41
Sacramento, CA 95814
916-654-4634

Ruth Anne Keister
Clean Cities Hotline
P.O. Box 12316
Arlington, VA 22209
1-800-C-CITIES

L.R. Davis
Director of Maintenance
Metropoliton Transportation Authority
900 Lyon Street
Los Angeles, CA 90012
213-291-7625

Toros Topologlu
Ministry of Transportation of Ontario
1201 Wilson Avenue
Downstream, Ontario
CANADA M3M 1JB
416-235-5017

Linda Bluestein
Contract Manager
National Alternative Fuels Hotline
P.O. Box 12316
Arlington, VA 22209
B00-423-1DOE (1363)

Steve Goguen
Office of Alternative Fuels
Transit Bus Pgm.
U.S. Department of Energy
1000 Independence Ave., S.W.
Room 5G086
Washington, DC 205B5
202-5B6-8044

Steve Barsony
Federal Transit Administration
U.S. Department of Transportation
400 - 7th Street, S.W.
Room 6423
Washington, DC 20590
202-366-0090

Vincent Demarco
Local Transit Authorities Alternative Fuel Initiative Program
Federal Transit Administration
U.S. Department of Transportation
400 7th Street, S.W., Room 6423
Washington, DC 20590
202-366-0090

Bill Blessing
Intermodal Surface Efficient Transportation Act
Federal Transit Administration
U.S. Department of Transportation
400 - 7th Street, S.W., Room 6423
Washington, DC 20590
202-366-0690

Donna Billinger
Intermodal Surface Efficient Transportation Act
U.S. Department of Transportation
400 - 7th Street, S.W.
Washington, DC 20590
202-366-0690

Mike Savonis
Congestion Mitigation & Air Quality (CMAQ) Improvement Program Funds
U.S. Department of Transportation
400 - 7th Street, S.W.
Washington, DC 20590
202-366-2080

Shiang Hsiung
Federal Transit Administration
U.S. Department of Transportation
400 - 7th Street, S.W., Room 6423
Washington, DC 20590
202-366-0090

Tam Baines
National Vehicle
& Fuel Emissions Laboratory
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4366

Phil Carlsan
National Vehicle
& Fuel Emissions Laboratory
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4366

Rick Rykowski
National Vehicle
& Fuel Emissions Laboratory
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4339

Organizations

American Bus Association
1100 New York Ave., N.W.,
Suite 1050
Washington, DC 20005
202-842-1645

Tim McGrath
Trucking Research Institute
American Trucking Association
2200 Mill Road
Alexandria, VA 22314
703-838-1966

Engine Manufacturers Association
401 North Michigan
Chicago, IL 60611
312-644-6610

Ginny Hobbs-Moore
CNG & LNG Research Programs
Gas Research Institute
8600 Bryn Mawr Avenue
Chicago, IL 60631
312-399-8100

Norm Yale
Project Manager
Gas Research Institute
8600 W. Bryn Mawr Avenue
Chicago, IL 60631
312-399-5414

Heavy-Duty Representatives
Association
4015 Marks Road, Suite 2B
Medina, OH 44256
216-725-7160

Susan Valek
Assistant Vice President
SAIC - Science Applications
International Corp
4242 Campus Point Court, M/S D-7
San Diego, CA 92121
619-535-7286

Chapter 9

Other Alternative & Clean Fuels

Other alternative fuels may hold promise for future use. These include biodiesels, hydrogen (in both fuel cells and internal combustion engines), liquefied natural gas, etc. More research, however, is needed and these fuels need to be proven in demonstration programs, infrastructure developed, etc. before they can become widely used. Many hurdles will have to be overcome for some of these fuels. But most Californians will be using a cleaner fuel beginning January 1, 1995. It's called reformulated gasoline. This chapter will look at some of the other alternatives and finish with a look at reformulated gasoline or RFG.

Biodiesel

Biodiesel is the name for a variety of diesel fuel alternatives based on methyl esters of vegetable oil or fats. It fits under the category of a renewable fuel because it is made from agricultural feedstocks such as soybean or rapeseed. Research on soy-based diesel is taking place in the United States, while European countries have been focusing on rapeseed derived biodiesel. Other possible feedstocks for biodiesel include bio-oils from corn, cottonseed, peanut, sunflower, canola, and rendered tallow (animal fat). The National Renewable Energy Laboratory is testing aquatic plants, such as microalgae, for possible of lipid (oil) production.

The fuel is made by a catalytic chemical process called trans-esterfication, using an alcohol (such as methanol) and a catalyst. Methanol is mixed with sodium hydroxide and then with soybean oil, letting the glycerine that is formed to settle. This forms fatty esters which is then separated into two phases, which allows easy removal of glycerol in the first phase. The remaining alcohol/ester mixture called methyl soyate is then separated and the excess alcohol is recycled. The ester are sent to the clean-up or purification processes which consists of water washing, vacuum drying and filtration.

The final fuel closely resembles conventional diesel fuel, with higher cetane number (a number that rates its starting ability and antiknock properties). Energy content, viscosity and phase changes are similar to petroleum-based diesel fuel. The fuel is typically blended with 20 percent low-sulfur diesel fuel.

The fuel is essentially sulfur free, emits significantly less particulates, smoke, hydrocarbons and carbon monoxide. Nitrogen oxides emissions (NOx) are similar to diesel and can be kept in check with catalytic converter technology. Biodiesel has a high flash point and has very low toxicity if digested. If is also biodegradable.

The biggest drawback of biodiesel is cost. The cost of the fuel is determined by the feedstock being used, but is estimated at approximately today at $2.50 to $6.00 a gallon because of the small-scale production. The U.S. Departments of Energy and Agriculture have estimated that large-scale production using today's technology could reduce biodiesel costs to $1.50 to $1.60 a gallon. And biodiesel from microalgae may cost as low as $1.00 a gallon.

Another drawback is that vehicle fuel lines and other components that would come in contact with the fuel would have to be changed because biodiesel can dissolve rubber. The fuel also clouds and stops flowing in lower temperatures than diesel, so fuel-heating systems or blends with diesel fuel would be needed in lower temperature climates.

In Europe, biodiesel use (blended with diesel) is growing because the price of petroleum fuel is three to four times what it is in the United States. According to the London *Daily Mail*, the price in December 1994 for Shell unleaded petrol in Britain was 240.5 pence a gallon or $3.92 U.S. per gallon (with the exchange rate at 100 pence or one (1) pound = $1.63 U.S.). In Holland the price is 309.13p a gallon ($5.04 per gallon); in France it is 291.4p a gallon ($4.75 per gallon) and in Germany it costs 386.85p a gallon ($6.31 a gallon). So, biodiesel can compete well with petroleum products in Europe.

According to *The Irish Times*, Ireland is looking at converting a portion of land to production of biodiesel feedstock. According to Pat Bell of the Irish Energy Centre, "There are currently 36,000 hectares of land under the set-aside system in Ireland. Only 1,000 hectares are being used to produce oil seed. The other

35,000 hectares are lying idle when they could be producing 30,000 tonnes of seed oil and returning a profit for their owners."

The article says that currently biodiesel produced from rapeseed is up to 20 pence a liter more expensive ($0.33 U.S. per liter or $1.24 U.S. per gallon) than ordinary diesel at the pumps. But the cost to produce biodiesel is expected to come down when production increases.

Biodiesel seems to be growing in popularity and people are looking to covert vehicles to using the alternative fuel. The London *Daily Mail* in its December 3, 1994, edition said that biodiesel conversion kits for Volkswagen Golf and Vento cars will be on sale within a year in England.

Research activities are underway in the U.S. to use biodiesel, especially for urban transit. Research is being sponsored by the U.S. Environmental Protection Agency and the U.S. Departments of Agriculture and Energy, as well as other private organizations, state and local government. Research has been conducted for both light-duty and heavy-duty applications (see list below).

And biodiesel seems to be gaining popularity with transit managers compared to other alternative fuels, according to a story in *Urban Transport News*. A recent survey shows that biodiesel ranks second behind compressed natural gas in popularity.

One-fifth of transit managers surveyed by St. Louis-based Fleishman-Hillard Research, in a survey for the National Biodiesel Board, rank biodiesel as the top choice alternative fuel for transit buses. One in six transit managers expects to use biodiesel over the next two years, the survey found.

"Biodiesel is gaining attention because it offers significant emissions reductions with no modifications to bus engines and transit infrastructures," said Kenlon Johannes, executive director of the National Biodiesel Board (NBB). NBB, which promotes and researches soy-based biodiesel, is funded by the United Soybean Board. Awareness of biodiesel has nearly tripled in the last two years, the survey found.

According to *Urban Transport News*, survey respondents most frequently mention smoke reduction and the fact that biodiesel does not require engine alterations as primary advantages of the fuel.

Much more needs to be demonstrated before biodiesel can be a fuel for vehicle use in the United States, and the price needs to become much more competitive with diesel.

Some Biodiesel Demonstration Programs in the United States

Location	*Research Done By*	*Vehicle*	*Purpose*
Columbia, MO	Univ of Missouri	3/4-ton truck	Emissions, power
Columbia, MO	Phil Blom	Heavy-duty tractor	General
Jefferson City, MO	Missouri Soy Assn.	3/4-ton truck	General
Kansas City, MO	Interchem	Toyota Camry	General
St. Louis, MO	City of St. Louis	100 vehicles	Emissions, general
St. Louis, MO	Mass Transit	47 transit buses	Emissions
Sioux Falls, SD	Mass Transit	2 transit buses	Emissions
State of Illinois	Dept. of Trans.	2 Light-duty + 6 snowplows	General
City of Gardena, CA	Municipal Bus Lines	2 transit buses	Emissions

Hydrogen

Hydrogen is the most abundant element in the universe, but is rarely found in its uncombined form on the earth. When combusted (oxidized) it creates only water vapor as a by-product ($4H + O_2 = 2 H_20$). When burned in an internal combustion engine, however, combustion also produces small amounts of nitrogen oxides and small amounts of unburned hydrocarbons and carbon monoxide because of engine lubricants. The exhaust is free from carbon dioxide.

Hydrogen is normally a gas and can be compressed and stored in cylinders. It can also be kept as a liquid, but the gas only turns liquid at temperatures of minus 423.2 degrees Fahrenheit (below zero)!

Hydrogen is mostly obtained by cracking hydrocarbon fuels, but it can be produced by electrolysis of water (using electricity to split water into hydrogen and oxygen) and photolysis (chemical decomposition).

The main problem with hydrogen is bulk storage required for fuel tanks. For an equivalent energy content of gasoline, liquid hydrogen and the required refrigeration system requires six to eight times more storage space than gasoline and compressed hydrogen gas requires six to ten times more storage space.

Automobile manufacturers have experimented with hydrogen as a fuel. Research vehicles have been produced by Daimler-Benz, BMW and Mazda. The Mercedes-Benz and BMW vehicles used liquid hydrogen. The Mazda vehicle stored its hydrogen as a gas in a metal-hydride lattice of shaved metal. Other vehicles have been built using compressed hydrogen, including two vehicles in Arizona operated by the American Hydrogen Association.

In California, Xerox® Corporation, with funding from the U.S. Department of Defense, demonstrated a solar-powered photovoltaic (PV) hydrogen fuel generating facility. The hydrogen was to be used in a small demonstration fleet of vehicles. The cost of a 33 kilowatt PV-hydro production facility was estimated at $1.4 million and could service five vehicles.

Also in California, Riverside Community College has been producing hydrogen via electrolysis for two service vehicles (light-duty pickup trucks). The hydrogen is compressed in cylinder/tanks and gives the pickups a range of 10 to 25 miles before needing to be refilled. This is adequate for the on-campus use of the vehicles. The college has also been training students in automotive maintenance and vehicle retrofits with an emphasis on hydrogen vehicles and engines.

Another development using hydrogen is as a blend of hydrogen and methane (natural gas) called Hythane. Preliminary information presented in mid-1994 at the 10th World Hydrogen Energy Conference in Cocoa Beach, Florida, says that a test car's exhaust using 30 percent hydrogen and 70 percent methane contained 80 percent less nitrogen oxides than U.S. EPA standards for 2003. This blend has much higher contents of hydrogen than other Hythane blends, which typically run about five percent.

Although hydrogen has a higher energy content than gasoline or diesel fuel, high production costs and low density have prevented its use as a transportation fuel in all but test programs and may never be cost-competitive with other fuels. It maybe 20 to 30 years or more to be a viable transportation fuel and then perhaps only in fuel-cell-powered vehicles.

Fuel-Cells

Fuel cells are used to provide power on manned space flights, and the technology could come "down to earth" to run automotive electric motors in vehicles. By combining — rather than burning — hydrogen and oxygen, electricity and water vapor are created as a by-product. Today's fuel cells are too bulky and costly, but promising new concepts are under development that would shrink both their size and price tag. And we could see practical fuel cells in use on vehicles by the end of the 1990s.

The fuel cell power system involves three basic steps. First, methanol, natural gas or another fuel containing hydrogen reacts with steam or is reformed to produce hydrogen. This hydrogen is then electrochemically combined with oxygen in the fuel cell.

Fuel cells operate like a battery. Hydrogen and air are fed to the anode and cathode, respectively, of each cell. These cells are stacked to make up the fuel cell stack. As the hydrogen diffuses through the anode, electrons are stripped off, creating direct current electricity. This electricity can be used directly in a DC electric motor or can be converted to alternating current.

Since the methanol or natural gas fuel is not burned, there is little or no pollution from the generation of electricity.

Fuel cells were first used in the space program. These units, based on an alkaline electrolyte, use pure hydrogen and oxygen stored as liquids on board the space craft. Another form of fuel cell uses phosphoric acid as an electrolyte to produce electricity and hot water. The South Coast Air Quality Management District (SCAQMD) has a phosphoric acid fuel cell

plant operating at its headquarters in Diamond Bar, Calif.

Another more advanced type of fuel cell is called a molten carbonate fuel cell and uses carbonate salts, which provide increased electrical efficiency over the earlier concepts. These operate at an elevated temperature and produces steam instead of hot water.

The world's largest molten carbonate fuel cell (MCFC) power plant, which promises nearly pollution-free electrical generation, was unveiled recently at Unocal Corporation's research center in Brea, Calif. The 250-kilowatt power plant was designed and built by M-C Power Corporation and its team members. The commercial demonstration project is being underwritten by the U.S. Department of Energy (DOE), Gas Research Institute (GRI), Electric Power Research Institute (EPRI), SCAQMD, Southern California Edison, Southern California Gas Company and the State of Illinois.

The fuel cell technology that seems to have the greatest use in vehicles is called the proton exchange membrane (PEM). This fuel cell is lighter than other types but basically works in the same manner.

At least two North American companies are working on fuel-cell powered buses. Ballard Power Systems Incorporated of North Vancouver, British Columbia, is the developer of a PEM fuel cell that converts hydrogen, natural gas or methanol fuel into electricity without combustion. It is working with Daimler-Benz, General Motors and the Dow Chemical Co. to develop zero-emission vehicles and stationary power plants. Ballard has already created a 120 kilowatt/hour, 20-passenger fuel-cell bus using stored, compressed hydrogen. The bus is under going testing by BC Transit. Ballard is also working on a full-size transit bus using methanol or natural gas as the "feedstock" to produce hydrogen for the fuel cell.

Another prototype bus is part of an effort by H Power, a Santa Barbara, California, bus manufacturer, and the federal Department of Energy to place the quiet and little-used fuel-cell technology beneath the hoods of buses, trucks, and cars across the country by the end of the decade. H Power uses methanol in its fuel cell stack. The company started working with buses because the power packs are currently too large for most passenger cars.

A Society of Automotive Engineers report says that using 650 pounds of liquid hydrogen can power a full-size electric transit bus for 3,000 miles. Such a bus would use a 150 kilowatt fuel cell at 55 to 65 percent efficiency.

Hybrid Vehicles

Hybrid electric vehicles (HEVs or "hybrids" for short) are basically electric vehicles that use something other than a battery as another energy source. Typically, the vehicle has a liquid or gaseous fuel-powered generator that runs at constant speeds to produce electricity to power the vehicle and usually to charge its batteries.

Hybrids allow EVs to have extended range, going further than a vehicle can travel on just the charge in its batteries. Being a hybrid would allow the vehicle to operate on only batteries within an urban/polluted area, and then switch to its turbine/generator outside the urban area. Such a hybrid can get 80 or more miles per gallon because the constant speed generator can be made to be very fuel efficient. The HEV also doesn't normally require recharging from an outboard power source.

The vehicle's generator can be gas turbine engine, which is widely used in power generation plants. It is highly efficient, but only when run at a constant speed. A typical automobile generator may operate at speeds ranging from 1,000 to 7,500 rpm.

A gas turbine generator is being designed for the Volvo Environmental Concept Car (see electric vehicle chapter).

All of the "Big Three" auto companies are working with the U.S. Department of Energy on independent hybrid electric vehicle programs. As part of the Clinton administration's "supercar" program, Ford announced a $122 million federal contract to design a hybrid within five years. GM is also working on developing a hybrid EV under the program. Chrysler is also looking at tomorrow's "supercar."

According to an article in the *Washington Times*, "The Big Three not only have to imagine this Supercar, they have to build it as part of the Partnership for a New Generation Vehicle. The billion-dollar consortium was created last year as part of a deal with the Clinton White House.... meeting the mandates of the PNGV, which is dubbed the Supercar program, will require technological breakthroughs in virtually every aspect of automotive design and engineering....

"So far, the consortium has targeted 16 high-priority research projects, though dozens of other ideas are under investigation. They fall into four basic categories: 1) Energy conversion (search for a new power source); 2) Energy storage; 3) Electrical and electronics; and 4) Mass reduction (lighter vehicles)."

Solar-Powered Vehicles

We probably won't be able to harness the sun's rays to power our regular vehicles. For one thing, photovoltaic (PV) cells are too inefficient. Even state-of-the-art PV cells only get up to around 20 percent efficiency. And you would need a large area of cells to create even a small amount of electricity. The PV cells used on the solar-powered "race cars" measure two meters by ten meters and produce only about 1,500 to 2,000 watts of electricity...about enough to power a blow-dryer for hair. That's the size of the PV panels used by the world's oldest solar cat race, The World Solar Challenge from Perth to Sydney, Australia.

According to a report on *Alternative Energy Network Online Today*, from November 16, 1994, "The solar-powered Aurora Q1 broke Australia's trans-continental record last week by crossing 2,485 miles from Perth to Sydney in 8 days — cutting the previous solar car record trip of 20 days by more than one-half. The 2,485 mile trip was sponsored by electronics and computer shop entrepreneur Dick Smith, owner of Australian Geographic magazine, with 60 businesses financing the $375,000 design and construction of the vehicle.

"The Aurora Q1 averaged 31 miles per hour on its journey. Smith and the Aurora team point out that the vehicle did not use the most efficient solar cells that are currently available, so the speed for future trips will be further increased. In the future, Smith believes, the role of solar panels in vehicles will be expanded to charge the batteries used for the electric systems on conventional cars."

Smith is probably correct in his estimates. Solar panels will probably provide a "trickle charge" for electric vehicle's batteries. Or, they may power an EVs heating/air-conditioning system to warm or cool the interior of a vehicle while parked. Solar cell "charging ports" for EVs, however may be used to charge batteries. The Los Angeles Dept. of Water and Power and Sacramento Municipal Utility District are both using solar "charging ports" for their EVs.

Into the Future...

As we move into the 21st Century, there will be other storage devices, fuels and vehicles in our future that have yet to be utilized, invented or discovered. Certainly, we will have to decrease our dependence on petroleum, if only because we have an estimated 60 years of oil resources left with today's known reserves.

Technologies such as ultra-capacitors, superconducting magnets, flywheels and other esoteric technologies may one day provide power sources for our vehicles. We will also see vehicles that get much higher mileage than the vehicles being used in the mid-1990s as engine efficiency levels increase and vehicle become lighter, using space-age composites and aerospace/defense industry materials.

In 1995, the California Energy Commission will publish the third edition of its *Energy Technologies Status Report*. This comprehensive report lists every known energy technology, its current status in development or usage, barriers to implementation of the technology and other information. The third edition will include a separate volume on transportation technologies and should give a good over-all discussion of each and every technology current known.

You will always underestimate the future.
— Charles F. Kettering

Biodiesel Contacts

Government

John V. Rosania, Jr.
Connecticut Transit
Hartford Division
100 Leibert Road
Hartford, CT 01641-0066
203-522-8101

Noni Strawn or Norm Hinman
Biofuels Information Center
National Renewable Energy Laboratory
1610 Cole Blvd.
Golden, CO 80401-3393
303-231-1947 or 303-231-1281

Janet Cushman
Biomass Prgm.
Short Rotation Woody Craps
Oak Ridge National Laboratory
P.O. Box 20008
Oak Ridge, TN 37831
615-574-7377

Dick Auld
Agronomy Department
Texas Technical University
P.O. Box 42122
Lovit, TX 79408
806-742-2838

John McClelland
U.S. Department of Agriculture
Office of Energy
1301 New York Ave., N.W.,
Room 1208
Washington, DC 20005
202-219-1941

John Ferrell
Program Manager
U.S. Department of Energy
1000 Independence Ave., S.W.
Washington, DC 20585
202-586-6745

Charles L. Peterson
University of Idaho
Dept. of Agricultural Engineering
Moscow, ID 83844
205-885-6182

Organizations

Bill Homlberg
President
American Biofuels Association
1925 N. Lynn Street, Suite 1050
Arlington, VA 22209
202-522-3392

Jeff Beller and Julia Delain
Biofuels America
RD 1, Box 19
Westerlo, NY 12193-9801
518-797-3377

Kenlon Johannes
Executive Director
National SoyDiesel Development Board
P.O. Box 104898
107 Williams Street
Jefferson City, MO 65110
314-635-3893 or
toll free 800- 841-5849

Tom Ryan
Southwest Research Institute
6220 Culebra Road
P.O. Drawer 28510
San Antonio, TX 78228
512-522-3192

Sustainable Farming
REAP - Canada
Box 125, Glenaladale House
Ste. Anne de Bellevue, Quebec
CANADA H9X 1C0
514-398-7743

United Soybean Board
16305 Swingley Ridge Dr., Suite 110
Chesterfield, MO 63107
314-530-1777

Hydrogen Contacts

Chuck Mizutani
Technology Evaluation Office
California Energy Commission
Energy Technology Development Division
1516 Ninth Street, MS-43
Sacramento, CA 95814
916-654-4636

Dr. Robert Zweig
2936 McAllister Street
Riverside, CA 92503
714-688-5474

Roy McAllister
American Hydrogen Association
216 South Clark Street, MS-103
Tempe, AZ 85281
602-921-0433

David E. Bruderly
Bruderly Engineering Associates
1826 N.W. 57th Terrace
Gainesville, FL 32065
904-377-0932

Greg Egan
Hydrogen Consult. Inc.
12420 N. Dumont Wy.
Littleton, CO 80125

Peter Hoffman
Editor
Hydrogen Letter
4104 Jefferson Street
Hyattsville, MD 20781
301-779-1561

Debbi L. Smith
National Hydrogen Association
1101 Connecticut Avenue, N.W.,
Suite 910
Washington, DC 20036
202-223-5547

Carl Helman or Ron Schaeffer
National Vehicle
& Fuel Emissions Laboratory
U.S. Environmentol Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4246 or 313-668-4279

Steve Rubin
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393
303-275-4065

David Swan
University of California, Davis
Davis, CA 95616
916-752-7434

Dr. Joseph Norbeck
College of Engineering – Center for Environmental Research and Technology (CE-CERT)
University of California, Riverside
Riverside, CA 92521

Susan Sullivan
Office of University Relations
University of California, Riverside
Riverside, CA 92351
909-787-5893

Michael Gurevich
Program Manager
U.S. Department of Energy
1000 Independence Ave., S.W.
Washington, DC 20585
202-586-6104

Fuel Cell Contacts

Ed Gillis
American Association for fuel Cells
A Project of Clean Air Revival, Inc.
50 San Miguel Avenue
Daly City, CA 94105

Editor
Fuel Cell News
American Fuel Cells Association
P.O. Box 65482
Washington, DC 20035
301-681-3532

Martin Gutstein
American Fuel Cells Association
P.O. Box 65482
Washington, DC 20035
301-681-3532

Roy McAllister
American Hydrogen Association
216 South Clark Street, MS-103
Tempe, AZ 85281
602-921-0433

Geoffrey Ballard
Chairman
Ballard Power Systems
107 - 980 West 1st Street
Vancouver, British Columbia
CANADA V7P 3N4
604-986-9367

Martin Gutstein
Fuel Cells Institute
P.O. Box 65481
Washington, DC 20035
301-681-3532

Peter Hoffman
Editor
Hydrogen Letter
4104 Jefferson Street
Hyattsville, MD 20781
301-779-1561

Debbi L. Smith
National Hydrogen Association
1101 Connecticut Avenue, N.W.,
Suite 910
Washington, DC 20036
202-223-5547

Steve Rubin
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401
303-231-1365

Susan Volek
Assistant Vice President
SAIC - Science Applications International Corp
4242 Campus Point Court, M/S D-7
San Diego, CA 92121
619-535-7286

David Swan
University of California, Davis
Davis, CA 95616
916-752-7434

Dr. Joseph Norbeck
College of Engineering – Center for Environmental Research and Technology (CE-CERT)
University of California, Riverside
Riverside, CA 92521

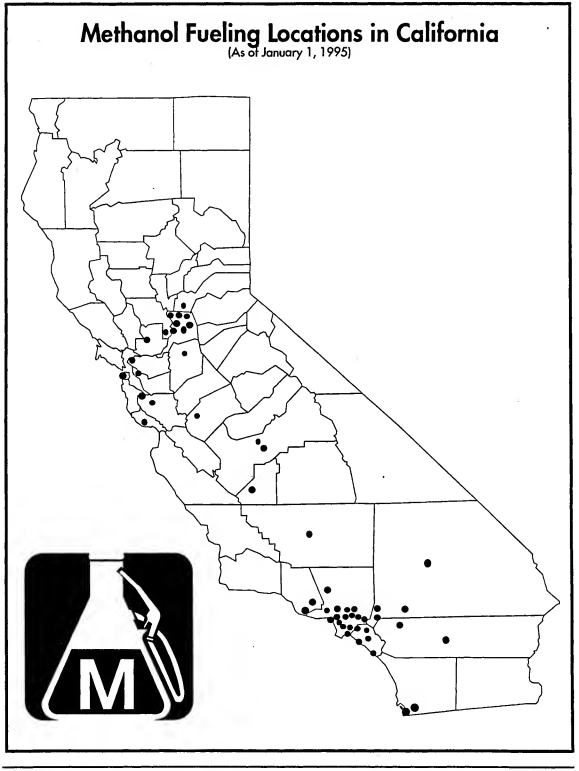
Susan Sullivan
Office of University Relations
University of California, Riverside
Riverside, CA 92351
909-787-5893

Pandit Patil
Program Manager, Propulsion Office
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585
202-586-8055

Carl Helman
National Vehicle
& Fuel Emissions Laboratory
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105
313-668-4246

Chapter 10

Locations of Alternative Fuel Facilities



Methanol Fueling Locations in California

(As of January 1, 1995)

Northern California

Davis
ARCO
705 Russell Blvd.

Fairfield
Chevron
2990 Travis Blvd.

Fresno
Chevron
4161 East Ventura Ave.
Texaco
3808 No. Blackstone Ave.

Oakland
Chevron
451 Hegenberger Road

Richmond
Exxon
12678 San Pablo Ave.

Roseville
Exxon
1000 Douglas Blvd.

Sacramento
ARCO
2225 16th Street
Chevron
3001 Zinfandel Drive
(Rancho Cordova)
Exxon
3430 Northgate Blvd.
Shell
8607 Elk Grove Blvd.
(Elk Grove)
Shell
730 29th Street
Shell
8090 Folsom Blvd.
Ultramar
4250 Madison Avenue
(North Highlands)

San Francisco
Shell
3035 Geary Street

San Jose
Exxon
890 Coleman Avenue

Santa Cruz
Chevron
404 Soquel Ave.

Santa Nella
Chevron
12801 Highway 33, South

Stockton
Chevron
2905 West Benjamin Holt

Sunnyvale
Exxon
696 El Camino Real

Southern California

Anaheim
Chevron
1801 South Harbor Blvd.

Bakersfield
ARCO
4100 California Ave.

Barstow
ARCO
1251 East Main Street

Coachella
ARCO
48-055 Grapefruit Blvd.

Culver City
ARCO
5884 Washington Blvd.
Shell
3801 No. Sepulveda Blvd.

Diamond Bar
Chevron
150 So. Diamond Bar Blvd.

Glendale
ARCO
3941 San Fernando Blvd.

Huntington Beach
Shell
19002 Magnolia St.

Kettleman City
Ultramar (Beacon)
33190 Hubert Way

Long Beach
ARCO
1785 Bellflower Blvd.

Los Angeles
ARCO
3675 Wilshire Blvd.
Shell
5657 Sunset Blvd.

Norwalk
Texaco
10710 Alondra Blvd.

Northridge
Shell
17000 Roscoe Blvd.

Ontario
ARCO
2430 South Euclid Ave.

Paramount
Shell
7512 Alondra Blvd.

Pasadena
Mobil
392 No. Lake Ave.

Riverside
Mobil
1147 University Avenue

San Bernardino
Shell
1973 Tippecanoe Ave.

San Diego
ARCO
3205 University Ave.
Chevron
1221 11th Ave.

San Juan Capistrano
Shell
26571 Junipero Serra Rd.

Santa Ana
ARCO
3414 Main Street

Santa Fe Springs
Chevron
11426 East Telegraph Rd.

Santa Monica
Chevron
1732 Lincoln Blvd.

Simi Valley
ARCO
25 West Tierra Rejada Rd.

South El Monte
Chevron
1625 Santa Anita Ave.
(Closing 2/5/93; to be relocated.)

Thousand Oaks
GTE Corporation
112 Lakeview Canyon Road

Upland
Mobil
411 South Mountain Ave.

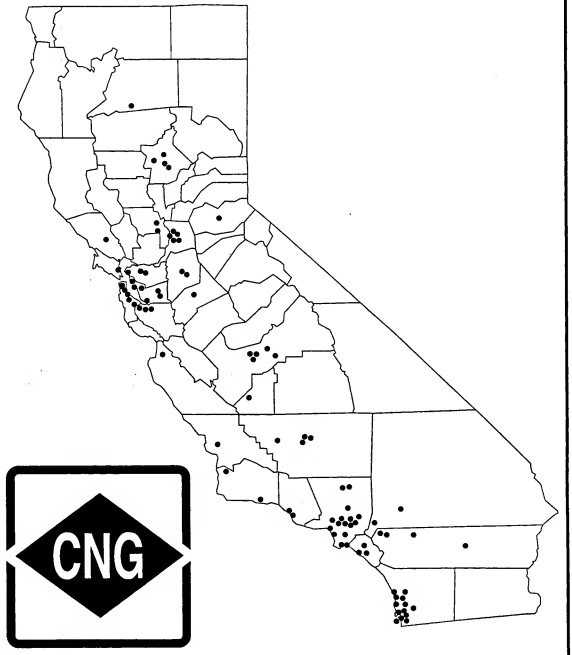
Valencia
Shell
24301 Valencia Blvd.

Ventura
ARCO
605 South Mills Road

Woodland Hills
Mobil
20101 Ventura Blvd.

Natural Gas Fueling Locations in California

(As of January 1, 1995 – Locations are Approximate)



Natural Gas Fueling Locations in California

(As of January 1, 1995)

Northern California

Anderson
- Anderson Unified School District

Auburn
- PG&E Service Center 333 Sacramento St.

Avenal
- Avenal State Prison

Bakersfield
- PG&E Service Center 4101 Wibble Road
- FleetStar 3305 Gulf Street
- Kern High School Dist. Kern High School

Belmont
- PG&E Service Center 1970 Industrial Way

Buttonwillow
- Elk Hills Naval Reserve

Chico
- City of Chico Yard

Clovis
- 1450 Herndan Ave.

Concord
- PG&E Service Center 1030 Detroit Ave.
- U.S. Post Office Concord Branch

Davis
- PG&E Service Center 316 L Street

Fresno
- PG&E Service Center 3224 East California
- City of Fresno 2101 "G" St.
- Viso Petroleum 2414 Monterey St.

Hayward
- PG&E Service Center 24300 Clawiter Road

Livermore
- PG&E Training Facility
- Lawrence Livermore Labs

Modesto
- 42B Seventh St

Oakland
- PG&E Service Center 4801 Oakport
- City of Oakland 7101 Edgewater Drive

Oroville
- City Corp. Yard
- Butte County Yard

Palo Alto
- City of Palo Alto

Poradise
- City Yard

Richmond
- PG&E Service Center 1100 South 27th St.

Sacramento
- PG&E Gas Load Center Front & "I" Streets
- PG&E Service Center 5555 Florin-Perkins
- Shell Oil 6490 Mack Road
- PG&E 4420 Alpine Ave.

Salinos
- PG&E Service Center 390 Griffin St.

San Francisco
- PG&E Service Center 3235 18th Street
- S.F. International Airport call 415-59B-7367
- PG&E 2270 Falsom St.

Sanger
- Gibbs Automated Fuels 3555 So. Academy Ave.

San José
- PG&E Service Center 30B Stockton Ave.

San Rofoel
- PG&E Service Center 1220 Andersen Drive

San Romon
- PG&E Tech. Center

Santo Rosa
- PG&E Service Center 3965 Occidental Rd.

South San Froncisco
- Olympian Oil 190 E. Grand Ave.

Stockton
- PG&E Service Center 4040 West Lane
- PG&E 1001 W. Charter Way

Sunnyvale
- Lockheed

Woodlond
- B.C. Stocking 341 Industrial Way

Southern California

Corlsbad
- SDG&E Service Center 5016 Carlsbad Blvd.

Chula Vista
- Chula Visto Ed. Ctr. B4 E. "J" St.

City of Industry
- UNOCAL 94B S. Alusa Ave.

Compton
- SoCal Gas 700 N. Long Beach Bl.

Corona
- SoCal Gas 414 W. Grand Ave.

Coronodo
- SDG&E Alameda Blvd. & 2nd St.

Covina
- SoCal Gas 534 Barranca Ave.

El Cojon
- UNOCAL 1090 W. Main St.

Encinitas
- Shell 160 Encinitas Blvd.

Escondido
- Shell Oil 780 W. El Narte Pkwy.

Garden Grove
- SoCal Gas 12631 Monarch St.

Glendole
- SoCal Gas Base 5610 San Fernanda Rd.

Galeta
- Santa Barbara Public Works 4330 Calle Real

Huntington Beach
- U.S. Postal Service 6771 Warner Ave.

Irvine
- City of Irvine 15029 Sand Canyon Rd.

Lancaster
- 670 Avenue I-B
- Edward AFB

Long Beach
- Long Beach Gas Dept. 2400 E. Spring St.
- Long Beach Gas Dept. 400 W. Broadway

Los Angeles
- County of L.A. Internal Service Division 1100 N. Eastern Ave.
- SoCal Gas Olympic Base 2424 E. Olympic Blvd.
- 1540 Santa Fe Ave.

Montebello
- Chevron 1500 Paramaunt Blvd.

Moreno Volley
- Shell 12301 Heacock

Norwalk
- UNOCAL 14960 Cormenita St.

Ontario
- City of Ontario 1440 Cucamonga Ave.

Otay Meso
- Texaco 2435 Otay Center Dr.

Oxnord
- SoCal Gas Oxnard Base 1650 Mountain View Ave.
- FleetStar Inc. 100 N. Del Narte Bl.
- SoCal Gas 1600 Patton Ct.

Pico Rivero
- SoCal Gas B101 S. Rosemead Bl.

Poway
- Poway School Dist. 13626 Twin Peaks Rd. Rancha Penasquitas
- SDG&E 12B49 Rancha Penasquitos Bl.

Riverside
- So. Cal Gas Riverside Base 4495 Howard Ave.

San Bernordino
- County of San Bern. 210 N. Lena Rd.

San Diego
- SDG&E, E. Service Center 6B75 Consolidated Way
- SDG&E, E. Service Center 175 11th Ave.
- SDG&E, E. Service Center 54BB Overland Ave.
- SDG&E Service Center 54BB Overland Ave.

San Luis Obispo
- San Luis Obispo USD 7B Prada Rd.

San Pedro
- SoCal Gas 755 W. Capitol Dr. Santo Maria

SoCol Gas
- 2310 S. Meredith Lane

Santa Monico
- SoCal Gas 1701 Stewart Street

Sun Valley
- Southern California MTA 11900 Branford St.

Thousand Polms
- Sunline Transit 32-505 Harry Oliver Trail

Von Nuys
- SoCal Gas Saticoy Base 16645 Saticoy St.

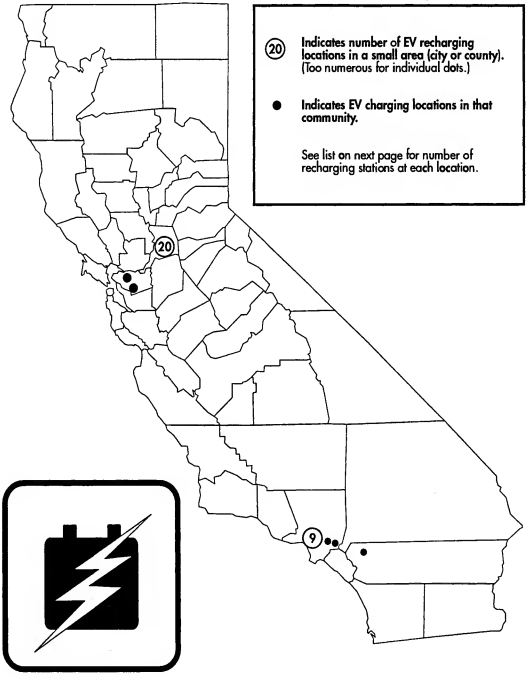
Vista
- UNOCAL 636 Sycomore St.

Westwood
- UCLA 1250 Compus Service

NOTE: Not all sites have full public access. Some are private; some have **limited public access** by arrangement with the local natural gas utility company. Please contact the local utility company in advance regarding specific locations.

Public Electric Vehicle Fueling Locations in California

(Public Recharging Hook-Ups As of February 1, 1995 – Locations are Approximate)



(20) **Indicates number of EV recharging locations in a small area (city or county). (Too numerous for individual dots.)**

● **Indicates EV charging locations in that community.**

See list on next page for number of recharging stations at each location.

Public EV Recharging Locations in California

(As of February 1, 1995)

Northern California

Lafayette

Lafayette BART Station
1 - Hughes Inductive

San Ramon

PG&E R&D Office
3400 Crow Canyon Rd.
1 - outlet
1 - Hughes Inductive

Sacramento

Bel Air Market
7465 Rush River Dr.
4 - west side of store front

Bel Air Market
5100 Laguna Blvd.
4 - east side of stare front

California Energy Commission
1516 Ninth St.
1 - behind building (Hughes Inductive)

Capitol Power Federal Credit Union
6341 Folsom Blvd.
1 - east side of bldg.

Plaza Park Tower Garage
9th & J Streets
3 - on first floor
2 - on second floor

Raley's Supermarket
10385 Folsom Blvd.
4 - east side of store

Raley's Supermarket
7847 Lichen Drive
4 - west side of stare

Sacramento City Garage
11th & I Streets
5 - on second floor

Sacramento City Garage
13th & I Streets
5 - on ground floor

Sacramento Co. Garage
7th & H Streets
5 - on ground level

SMUD Building
6701 4th Street
1 - by front door

SMUD Building
6201 S Street
10 - on west side

Sacramenta Metropolitan Airport Long Term Parking
5 - near toll gate
1 - 480 volt for EV Shuttle Bus

Sacr. Metro AQMD
8475 Jackson Rd.
2 - north side of bldg.

Sacramento Natural Foods Coop
1900 Alhambra Bl.
1 - near SW corner

Sacramento Public Parking Garage
1325 J Street
3 - near gate

Sacramenta Public Parking Garage
10th & L Streets
2 - 2nd level

Sacto Regional Transit Light Rail Station
Butterfield Station
15 - next ta platform

Sacto Regional Transit Light Rail Station
Manlove Station
16 - east side of lot

Wells Fargo Building
500 Capitol Mall
3 - on first deck

Southern California

Burbank

CALSTART Facility
3601 Empire Ave.
1 - near entrance

Chatsworth

Chatsworth Metrolink Station (MTA and DOT)
21510 Devonshire St.
2 - in parking lot

Diamond Bar

Sauth Coost AQMD
21865 E. Copley Dr.
17 - in parking lot

Hollywood

Cherokee Electric Parking Garage
1710 N. Cherokee Ave.
5 - in garage

Los Angeles

Graham & James Bldg.
801 S. Figueroa
6 - in parking structure

L.A. Convention Center
1201 S. Figueroa St.
4 - in parking structure

LADWP General Ofc. Bldg.
111 N. Hope St.
12 - in parking area
1 - Hughes Inductive

Riverside

Riverside City Halll
3900 Main St.
4 - in parking garage

Rosemead

SCE Facility
2244 Walnut Grave Ave.
8 - in parking lot

Sun Valley

LADWP – Truesdale Cntr.
11797 Trusedale St.
2 - in parking lot

Sylmar

Sylmar Metrolink Station (MTA)
12219 N. 1st Street
2 - in parking lot

West Los Angeles

LADWP – West L.A. District Office
1394 S. Sepulveda Bl.
2 - on pedestals

Note: No payment or fees are currently being collected for charging Electric Vehicles at public EV charging locations.

Chapter 11

Where Do We Go From Here?

The future is still uncertain when it comes to alternative fuels. Much work needs to be done at all levels to assure competition in the transportation fuel marketplace. Gasoline is going through a major change as California transitions to reformulated gasoline, and petroleum products will continue to be the dominant transportation fuel for many years (if not decades) to come. The Energy Commission forecasts, however, that by 2010, nearly 29 percent of the light-duty vehicles in California could be fueled by something other than gasoline or diesel. The Commission estimates that five million methanol-powered flexible fuel vehicles could be on the road, up to two million electric vehicles could be on the road, about one million natural gas vehicles could be on the road, and up to one-half million vehicles could be fueled by LPG. All combined, that means that more than ten million vehicles could be running on fuels other than gasoline or diesel.

To get there requires much work over the next 15 years. It also requires that fleets and fleet managers comply with current regulations to help the state realize its goals of cleaner skies and less dependency on petroleum. It requires education of fleet drivers and of the general public about clean, alternative fuels. It also requires cooperation between varying competing interests.

No one fuel is expected to be the "winner" over any other. Each of the fuels has its place in tomorrow's energy picture...just like solar, wind, geothermal, nuclear and natural gas all have a place in producing California's electricity. By using a number of different transportation fuels, California and its residents will be the "WINNERS."

The state continues its private/public alliances with the establishment of the **California Alternative Fuel Vehicle Partnership**. Through discussion, teamwork, sharing of ideas and problems; and through the talents, resources and successes that California already enjoys...the state will move forward into the next decade.

For general information about alternative transportation fuels in California contact:

California Energy Commission
Transportation Technology & Fuels Office
1516 Ninth Street, MS-41
Sacramento, CA 95814
Phone: 916-654-4634

Also contact:
U.S. Department of Energy
National Alternative Fuels Hotline
P.O. Box
Arlington, VA 22209
Phone: 1-800-423-1DOE

Other information about the various fuels can be obtained from the lists of organizations, fuel providers, companies and people at the end of each chapter.

Our grand business is not to see what lies dimly in the distance, but to do what lies clearly at hand.

– Carlyle

Glossary

AFTER–MARKET – broad term that applies to any change after the original purchase, such as adding equipment not a part of the original purchase. As applied to alternative fuel vehicles, it refers to conversion devices or kits for conventional fuel vehicles.

ALTERNATIVE FUELS - as defined by the National Energy Policy Act (EPAct) the fuels are: methanol, denatured ethanol and other alcohols, separately or in mixtures of 85 percent by volume or more (or other percentage not less than 70 percent as determined by U.S. Department of Energy rule) with gasoline or other fuels; CNG; LNG; LPG; hydrogen; "coal-derived liquid fuels;" fuels "other than alcohols" derived from "biological materials;" electricity, or any other fuel determined to be "substantially not petroleum" and yielding "substantial energy security benefits and substantial environmental benefits."

ALTERNATIVE FUEL VEHICLE (AFV) – motor vehicles that run on fuels other than petroleum-based fuels. As defined by the National Energy Policy Act (EPAct), this excludes reformulated gasoline as an alternative fuel.

BI-FUEL VEHICLE – a vehicle with two separate fuel systems designed to run on either an alternative fuel or conventional gasoline, using only one fuel at a time. These systems are advantageous for drivers who do not always have access to an alternative fuel refueling station. Bi-fuel systems are usually used in light-duty vehicles.

BIODIESEL – a biodegradable transportation fuel for use in diesel engines that is produced through the transesterfication of organically-derived oils or fats. It may be used either as a replacement for or as a component of diesel fuel.

BRITISH THERMAL UNIT (Btu)– a standard unit for measuring heat energy. One Btu represents the amount of heat required to raise one pound of water one degree Fahrenheit (at sea level).

CERTIFICATION – process by which a motor vehicle, motor vehicle engine, or motor vehicle pollution control device satisfies the criteria adopted by the California Air Resources Board (CARB) for the control of specified air contaminants from vehicular sources (Health & Safety Code §39018). Certification constitutes a guarantee by the manufacturer that the engine will meet certain standards at 50,000 miles; if not, it must be replaced without change.

CLEAN FUEL VEHICLE – is frequently incorrectly used interchangeably with "alternative fuel vehicle." Generally, refers to vehicles that use low–emission, clean–burning fuels. Public Resources Code §25326 defines clean fuels, for purposes of the section only, as fuels designated by CARB for use in LEVs, ULEVs or ZEVs and include, but are not limited to, electricity, ethanol, hydrogen, liquefied petroleum gas, methanol, natural gas, and reformulated gasoline.

CLUNKERS – also known as gross–polluting or super–emitting vehicles, i.e., vehicles that emit far in excess of the emission standards by which the vehicle was certified when it was new.

COMPRESSED NATURAL GAS (CNG) – natural gas that has been condensed under high pressure, typically between 2,000 and 3,600 pounds per square inch, held in a container. The gas expands when released for use as a fuel.

CONVERSION – device or kit by which a conventional fuel vehicle is changed to an alternative fuel vehicle

CONVERTED VEHICLE – a vehicle originally designed to operate on gasoline that has been modified or altered to run on an alternative fuel.

CORPORATE AVERAGE FUEL ECONOMY (CAFE) – a sales–weighted average fuel mileage calculation, in terms of miles per gallon, based on city and highway fuel economy measurements performed as part of the federal emissions test procedures. CAFE requirements were instituted by the Energy Policy and Conservation Act of 1975 (89 Statute. 902) and modified by the Automobile Fuel Efficiency Act of 1980 (94 Statute. 1821). For major manufacturers, CAFE levels are currently 27.5 miles per gallon for light–duty automobiles. CAFE standards also apply to some light trucks. The Alternative Motor Fuels Act of 1988 allows for an adjusted calculation of the fuel economy of vehicles that can use alternative fuels, including fuel–flexible and dual–fuel vehicles.

DUAL–FUEL or BI-FUEL VEHICLE refers to a vehicle capable of operating on two different fuels, in distinct fueling systems, such as compressed natural gas and gasoline.

E10 (Gasohol) – a mixture or 10 percent ethanol, 90 percent unleaded gasoline.

E85 – a mixture or 85 percent ethanol, 15 percent unleaded gasoline used in flexible fuel vehicles.

ENERGY/FUEL DIVERSITY – policy that encourages the development of energy technologies to diversify energy supply sources, thus reducing reliance on conventional (petroleum) fuels; applies to all energy sectors.

ENERGY/FUEL SECURITY – policy that considers the risk of dependence on fuel sources located in remote and unstable regions of the world and the benefits of domestic and diverse fuel sources.

ETHANOL (also know as Ethyl Alcohol or Grain Alcohol, CH_3CH_2OH) – a liquid that is produced chemically from ethylene or biologically from the fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues from crops or wood. Used in the United States as a gasoline octane enhancer and oxygenate, it increases octane 2.5 to 3.0 numbers at 10 percent concentration. Ethanol can also be used in higher concentration (E85) in vehicles optimized for its use.

ETHYL TERTIARY BUTYL ETHER (ETBE) – an aliphatic ether similar to MTBE. This fuel oxygenate is manufactured by reacting isobutylene with ethanol Having high octane and low volatility characteristics, ETBE can be added to gasoline up to a level of approximately 17 percent by volume. ETBE is used as an oxygenate in some reformulated gasolines.

EV (ELECTRIC VEHICLE) – a vehicle powered by electricity, usually provided by batteries but may also be provided by photovoltaic (solar) cells or a fuel cell.

FLEXIBLE FUEL VEHICLE (FFV) – a vehicle that can operate on either alcohol fuels (methanol or ethanol) or regular unleaded gasoline or any combination of the two from the same tank.

FUEL CELL – an electrochemical engine with no moving parts that converts the chemical energy of a fuel, such as hydrogen, and an oxidant, such as oxygen, directly into electricity. The principal components of a fuel cell are catalytically activated electrodes for the fuel (anode) and the oxidant (cathode) and an electrolyte to conduct ions between the two electrodes, thus producing electricity.

GASOHOL – in the United States, gasohol (E10) refers to gasoline that contains 10 percent ethanol by volume. This term was used in the late 1970s and early 1980s but has been replaced in some areas of the country by terms such as E-10, Super Unleaded Plus Ethanol, or Unleaded Plus.

HYBRID VEHICLE – usually hybrid EVs, a vehicle which employs a combustion engine system together with an electric propulsion system. Hybrid technologies expand the usable range of EVs beyond what an all–electric–vehicle can achieve with batteries only.

ILEV (Inherently Low Emission Vehicle) – term used by federal government for any vehicle that is certified to meet the California Air resources Board' Transitional Low Emission Vehicle (TLEV) standards and does not emit any evaporative emissions.

INFRASTRUCTURE – generally refers to the recharging and refueling network necessary to successful development, production, commercialization and operation of alternative fuel vehicles, including fuel supply, public and private recharging and refueling facilities, standard specifications for refueling outlets, customer service, education and training, and building code regulations.

LEV (LOW EMISSION VEHICLE) – a vehicle certified by the California Air Resources Board to have emissions from zero to 50,000 miles no higher than 0.075 grams/mile (g/mi) of non-methane organic gases, 3.4 g/mi of carbon monoxide, and 0.2 g/mi of nitrogen oxides. Emissions from 50,000 to 100,000 miles may be slightly higher (See chart in Chapter 2.)

LNG (LIQUEFIED NATURAL GAS) – natural gas that has been condensed to a liquid, typically by cryogenically cooling the gas to minus 327.2 degrees Fahrenheit (below zero).

LPG (LIQUEFIED PETROLEUM GAS) – a mixture of gaseous hydrocarbons, mainly propane and butane that change into liquid form under moderate pressure. LPG or propane is commonly used as a fuel for rural homes for space and water heating, as a fuel for barbecues and recreational vehicle, and as a transportation fuel. It is normally created as a by-product of petroleum refining and from natural gas production. California does not consider propane as an alternative to petroleum because of its direct links to oil, though it is listed in federal regulations and laws as an alternative fuel.

M85 – a blend of 85 percent methanol and 15 percent unleaded regular gasoline, used as a motor fuel in flexible fuel vehicles.

M100 – 100 percent (neat) methanol used as a motor fuel in dedicated methanol vehicles, such as some heavy-duty truck engines.

METHANE (CH_4) – the simplest of hydrocarbons and the principal constituent of natural gas. Pure methane has a heating value of 1,1012 Btu per standard cubic foot.

METHANOL (also known as Methyl Alcohol, Wood Alcohol, CH_3OH) – a liquid formed by catalytically combining carbon monoxide (CO) with hydrogen (H_2) in a 1:2 ratio, under high temperature and pressure. Commercially it is typically made by steam reforming natural gas. Also formed in the destructive distillation of wood.

METHYL TERTIARY BUTYL ETHER (MTBE) – an ether manufactured by reacting methanol and isobutylene. The resulting ether has a high octane and low volatility. MTBE is a fuel oxygenate and is permitted in unleaded gasoline up to a level of 15 percent. It is one of the primary ingredients in reformulated gasolines.

NGV (NATURAL GAS VEHICLE) – vehicles that are powered by compressed or liquefied natural gas.

OFF–ROAD – any non–stationary device, powered by an internal combustion engine or motor, used primarily off the highways to propel, move, or draw persons or property including any device propelled, moved, or drawn exclusively by human power, and used in any of the following applications: marine vessels, construction/farm equipment, locomotives, utility and lawn and garden equipment, off–road motorcycles, and off–highway vehicles.

ORIGINAL–EQUIPMENT MANUFACTURER (OEM) – refers to the manufacturers of complete vehicles or heavy–duty engines, as contrasted with remanufacturers, converters, retrofitters, up-fitters, and repowering or rebuilding contractors who are overhauling engines, adapting or converting vehicles or engines obtained from the OEMs, or exchanging or rebuilding engines in existing vehicles.

OXYGENATE –a term used in the petroleum industry to denote octane components containing hydrogen, carbon and oxygen in their molecular structure. Includes ethers such as MTBE and ETBE and alcohols such as ethanol or methanol. The oxygenate is a prime ingredient in reformulated gasoline. The increased oxygen content given by oxygenates promotes more complete combustion, thereby reducing tailpipe emissions.

PARTICULATE MATTER (PM) – Unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. A chief component of exhaust emissions from heavy-duty diesel engines.

PROPANE – See LPG (Liquefied Petroleum Gas).

RATE–BASING – refers to practice by utilities of allotting funds invested in utility Research Development Demonstration and Commercialization and other programs from ratepayers, as opposed to allocating these costs to shareholders.

REFORMULATED GASOLINE (RFG) – gasolines that have had their compositions and/or characteristics altered to reduce vehicular emissions of pollutants.

REID VAPOR PRESSURE (RVP) – a standard measurement of a liquid's vapor pressure in pounds per square inch at 100 degrees Fahrenheit. It is an indication of the propensity of the liquid to evaporate.

RETROFIT – broad term that applies to any change after the original purchase, such as adding equipment not a part of the original purchase. As applied to alternative fuel vehicles, it refers to conversion devices or kits for conventional fuel vehicles. (Same as "aftermarket".)

TAME (TERTIARY AMYL METHYL ETHER) – another oxygenate that can be used in reformulated gasoline. It is an ether based on reactive C_5 olefins and methanol.

TLEV (TRANSITIONAL LOW EMISSION VEHICLE) – a vehicle certified by the California Air Resources Board to have emissions from zero to 50,000 miles no higher than 0.125 grams/mile (g/mi) of non-methane organic gases, 3.4 g/mi of carbon monoxide, and 0.4 g/mi of nitrogen oxides. Emissions from 50,000 to 100,000 miles may be slightly higher (See chart in Chapter 2.)

ULEV (ULTRA-LOW EMISSION VEHICLE) – a vehicle certified by the California Air Resources Board to have emissions from zero to 50,000 miles no higher than 0.040 grams/mile (g/mi) of non-methane organic gases, 1.7 g/mi of carbon monoxide, and 0.2 g/mi of nitrogen oxides. Emissions from 50,000 to 100,000 miles may be slightly higher (See chart in Chapter 2.)

WARRANTY – seller's guarantee to purchaser that product is what it is represented to be and, if it is not, that it will be repaired or replaced. Within the context of vehicles, refers to an engine manufacturers guarantee that the engine will meet "certified" engine standards at 50,000 miles or the engine will be replaced. Retrofits will generally void an engine warranty.

ZEV (ZERO EMISSION VEHICLE) – any vehicle that is certified by the California Air Resources Board to have zero tailpipe emissions. The only vehicles that currently qualify at ZEVs are electric vehicles (EVs).

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Appendix A

California Alternative Fuel Vehicle Partnership Symposium Session Summary

CAFVP Forum Deemed a Success by Organizers

SACRAMENTO, February 2, 1995 – The first-ever forum of the California Alternative Fuel Vehicle Partnership held January 10 – 11 in Sacramento was declared an unqualified success by its organizers. The Partnership is an informal alliance of fleet managers, fuel providers, vehicle and equipment manufacturers, educational institutions and regulators supportive of the emerging alternative fuel vehicle industry.

Co-chairs Susan Patterson of California Energy Commission and Greg Vlasek of California Natrual Gas Vehicle Coalition expressed pleasure with both the attendance and participant response. "We had more than the 300 participants we'd planned for," said Vlasek. "The majority were fleet managers, which was an important goal of the steering committee. Energy levels in all the working sessions was high. People liked what we offered for the price (only $40 for the two days) and they asked for more. And, we generated lots of good ideas and discussion of solutions to market barriers. Our goals for the forum were definitely met. Now we've got to find ways to implement what we learned."

The forum consisted of a panel-led orientation/update on Alternative Fuel Vehicle market and regulatory issues the first day. The second day was devoted to a series of focus group sessions on six key industry topics (list). The Partnership steering committee promised to synopsize the discussion from these sessions for distribution to participants as well as policy-makers and thought leaders throughout the state and nationally. The forum also included a 20 vehicle alternative fuel ride-and-drive coordinated by the California Department of General Service's Office of Fleet Administration, but heavy rains and flooding effectively canceled the event.

Summaries of the six key panels' conclusions and solutions follow on the next few pages. The conclusions and solutions do not necessarily represent the views of the California Energy Commission, its management or its staff.

AFV MECHANICS TRAINING SESSIONS

Barriers	Solutions
• Inadequate training/maintenance support from after-market manufacturers and OEMs	• Require training more training/support in bid specs
• Lack of awareness of training opportunities • Who provides training for AFVs?	• AFV communication network • Training providers advertise more
• Management does not acknowledge importance of AFV training needs, for safety, success of program.	• Upward communication to management
• Warranty and verification of work • How do we assure quality training? • Basic safety and orientation lacking in some cases	• Standardized training, qualification • Better technical/service manuals • Industry self-auditing
• Lack of funding for training • Lack of time/back-up staff for training • Need flexibility of training options	• More training available i.e. comm colleges • AFV Net - Alt fuels bulletin board 1-800 684-4NGV • Need mobile service technicians for small fleets • Home study
• Lack of knowledgeable instructors	• Standardized training, qualification • Manufacturers' "train the trainer" program
• Additional vehicles needed for "spares/ backup"	• Retain conventional vehicles for back-up while in AFV pilot mode, or arrange for back-up pool with other fleets.

OEM ISSUES SESSIONS

Barriers	Solutions
• Lack of model availability • Fleets predisposed against certain makers that have or will have AFVs available (e.g., "foreign" maker AFVs)	• Provide OEMs with regional, state and national data on fleet AFV preferences and acquisition plans.
• Incremental costs are increasing • Incentives diminishing • Fleet manager not be able to justify higher cost of AFVs • Fleets need incremental cost "buy down" • Fleets need an affordable electric vehicle	•
• Production problems result in delays (i.e. tanks unavailable from vendor) • AFVs are low priority for OEMs • State budget cycle conflicts with the order cut-off dates for many AFVs, so fleets are not able to buy AFVs through the state bid	• Maintain political pressure for performance based, long range air and energy standards that create a competitive market among fuels
• Lack of information on terms of warranties • Dealership generally informed on maintenance, warranties and other issues • Uncertainties on conversions exist; OEMs will not support conversions • No-cost maintenance package on FFVs, no longer available	•
• Maintenance costs are higher for FFV's, especially oil • Some fleets can lower cost by performing maintenance in-house • Lack of technical training for AFV dealers and fleet managers	•
• OEM strategy in LEV compliance places more emphasis on meeting LEV regulations with gasoline vehicles, since fleet credits are emission based, not fuel based. • Gasoline vehicles will meet LEV requirements without incremental cost and range barriers.	•

RETROFIT REGULATIONS SESSIONS

Barriers	Solutions
• Bureau of Automotive Repair (BAR) inspection sometimes slows production on a vehicle for up to a month. Appointments hard to get and keep, given BAR constraints, installer production needs and customers need for vehicle.	• Ask ARB to immediately reassess the BAR's role in the inspection process of NGVs • Industry must demonstrate ability to self-certify.
• BAR contract employees have no knowledge or understanding of the products they are required to inspect	• Ask ARB to immediately reassess the BAR's role in the inspection process of NGVs
• Degradation/endurance testing requirements required by the ARB are too costly and time consuming adding to the products final cost, reducing available engine families for conversion forcing smaller companies to not be able to compete.	• Direct various retrofit manufacturers to seek AB2766 funding approval for financing ARB testing requirements for future engine families. • Assist retrofit manufacturers with regional market surveys of future vehicle purchase needs for fleet buyers.
• After-sale support from retrofit manufacturers is uncertain and inconsistent.	• Seek more prominent and clearer definitions of NGV "Kit" manufacturers support and service programs after their respective warranties have expired.
• Existing conversions don't always compare well with OEM product.	• Industry needs to demonstrate it's ability to properly support and service the current NGVs in the field.

PROCUREMENT STRATEGIES SESSIONS

Barriers	Solutions
• Where public fleet benefits for state master contract, Coalitions need to fill gap for private fleets in AFV purchases.	
• Need better distribution of bid information and needs.	• Develop information network i.e. publications, internet to make AFV issues available to all.
• Find incentive moneys.	• Broaden definition of who receives incentives moneys. Place public value i.e. clean air as a determining factor in who and how much is received.
• State should include AFVs on the state contract.	• Users of the State Equipment Council to look at specifications for alternative fuel buses.
	• Piggyback on federal contract or buy AFVs from the Federal government. (Have Fed's purchase and then sell to other govemment agencies) • Lobby DOE to pool EPACT purchase resources. • Regional coalitions pool purchasing power with private and public fleets and award contract for AFVs.
	• Extended or set realistic manufacture's cutoff dates.

INFRASTRUCTURE SESSIONS

Barriers	Solutions
• Lack of fueling knowledge.	• Develop training to educate drivers and managers
• Not enough stations (specifically natural gas), or limited access to existing stations • Liabilities and billing costs too much for small fleets to provide public access	• Expand and allow others to use existing facilities • More "outside-the-fence -line" fueling outlets • More mobile refueling options • Fleets suggested multifuel dispensers throughout the country. • Fuel provider industry offer insurance to reduce liability
• Capital cost for fueling is higher than gasoline • Funding for infrastructure needed (particularly natural gas)	• Industry needs to help promote, develop and communication with funding sources and financial market to increase opportunities
• Permitting by cities is an issue	• Standardize bid specifications • Improve education of/communication with building/safety officials
• Too many fueling card accounts needed	• Develop a universal fueling card for fuel access to any station throughout the country • Standardize bid specifications for transactions and billing
• Location of stations not known.	• Provide signage visible along the freeways • Industry provide maps and information

FUNDING & INCENTIVES SESSIONS

Barriers	Solutions
	TAILOR INCENTIVES TO THE USER • Incentives should occur as close to the point of purchase as possible; dealership-administered rebates for example. • Incentives should be given directly to manufacturers to lower purchase costs and reduce fleet paperwork. • Leasing options could remove high initial purchase price barriers by either spreading the higher cost of the AFV or passing through an otherwise inapplicable tax credit to public fleets. • Incentives should be specific to vehicle type. Heavy-duty vehicles need specialized incentives because of higher emissions/ differential cost/and life. • Incentives should be available for conversions. • Incentives should be available for infrastructure. • Focus on the large fleets where incentives are most cost-effective. • Fleet incentives should be in place for a set amount of time to allow for planning and market development (5 to 10 years).
	SOURCES OF INCENTIVE FUNDING • Waive vehicle registration fees for AFVs for a designated period of time (e.g., Arizona refunds 40 percent of the vehicle registration fee for AFVs.) • State tax exemption for the purchase price of an AFV for a designated and consistent period of time. • Waive fuel tax for alternative fuels for a designated period of time. This would especially benefit fleets with heavy-duty vehicles and high mileage and potentially compensate for higher purchase prices. • Reintroduce legislation that charges vehicle registration fees based on actual vehicle emissions determined during the smog check. • The California Alternative Fuel Vehicle Partnership should disseminate information on opportunities for fleets to lobby the State and federal government for incentive funding.

FUNDING & INCENTIVES SESSIONS (continued)

Barriers	Solutions
MOBILE EMISSION REDUCTION CREDITS • Fleets that might generate mobile source credits through early compliance with district fleet rules or with pre-1998 ZEVs have no market in which to sell their credits. • Some credits are devalued over time • Paperwork and bureaucracy surrounding the accumulation of credits makes them ineffective. • Lack of clear definition of heavy-duty LEV and a phase-in schedule has hindered opportunities to generate credits from these vehicles. (E.g., schoolbuses) • Lack of viable low cost emissions testing and monitoring methodologies – or reduction estimating protocols – substantially devalues long term credit value	• More education is required to "sell" the advantages of generating mobile credits. trading and/or selling among sources (water, air,etc.) should be allowed. • AQMDs should take the initiative to create model stationary/model credit trading projects. • Employee trip reduction rules should be developed that recognize reduced emissions when employer fleets use AFVs. • Industry should be active in promoting an aggressive HDV emission credit program by ARB
	POTENTIAL FOR "GROUP BUYS" • Large private fleets can negotiate for large purchases directly with the manufacture, thus assuring the manufacturer of a market while securing lower prices. CAFVP may have a role in notifying smaller private fleets when there are opportunities to "piggy back" larger fleet orders. • The State and CAFVP/regional coalitions could coordinate public AFV fleet purchases statewide to use large order leverage. The state could time this order to add to a private sector effort.

Appendix B

Attendees at California Alternative Fuel Vehicle Partnership Symposium Sacramento – January 10 to 11, 1995

AKCHURIN, KARI
Manager
Olympian Oil Company
260 Michele Ct.
Sa. San Francisco, CA 94080
415-873-8200

ALLISON, MARY
Mgr. Fleet & Maint. Opr.
Paratransit., Inc.
4410 Power Inn
Sacramento, CA 95826
916-443-0276

ALTREE, CHUCK
Transportation Supv.
Linden Unified School Dist.
18527 E. Main St.
Linden, CA 95236
209-887-3020

AMADOR, VIKKI
Parts Sales Manager
Valley Detroit Diesel Allison
13644 Nelson Ave.
City of Industry, CA 91746
818-855-1386

ANDERSON, GARY
Funding Agent
CNG Leasing
5775 Bonnie Lane
Paradise, CA 95967
916-877-2938

ANSELMO, BENNIE
VP, Equip. Maint & Const.
Norcal Waste Systems Inc.
5 Thomas Mellon Cr. #304
San Francisco, CA 94134.
415-330-1000

AGRENTINE, ALAN
Associate Energy Assoc.
California Energy Commission
1516 Ninth St., MS-41
Sacramento, CA 95814
916-654-4689

ARLIN, AERON
Environmental Rep.
Western States Petrol. Assoc.
505 N. Brand Blvd. Ste #1400
Glendale, CA 91203
818-543-5333

ASSADIAN, LINDA
Major Acct. Rep.
PG&E
5555 Florin-Perkins Rd.
Sacramento, CA 95826
916-386-5019

AVERS-JOHNSON, DARLENE
Deputy Dir., Interagency Sup.
State Dept. of General Svc.
1325 J St., Ste 1910
Sacramento, CA 95814
916-445-7213

BARNETT, SUSAN
Environmentol Cord.
City of Lancaster
44933 N. Fern Ave.
Lancaster, CA 93534-2461
805-723-6100

BARRETT, CHUCK
Western Sales Office
Cummins West Inc.
788 Sandoval Way
Hayward, CA 94544
510-351-6101

BATES, JOHN
Transit Sys. Cord.
San Luis Obispo RT
1150 Osos St., Ste 206
San Luis Obispo, Ca 93401
805-781-4467

BELL, ALBERT
Analyst
Dept. of Motor Vehicle
2415 First Ave.
Sacramento, CA 95818
916-657-6037

BELOTE, DEWAIN
California Liaison
Ford Motor
Rm 236 WHQ American Rd.
Dearborn, MI 48121
313-390-3073

BLEEKER, PAUL
VP - Operations
Cummins West, Inc.
788 Sandoval Way
Hayward, CA 94544
510-351-6101

BERENY, JUSTIN
Owner
Electric Vehicle Info. Services
P.O. Box 6025
Moraga, CA 94556
510-299-1829

BESSO, BOB
Recycling Manager
Sunset Scavenger Norcal
Tunnel Ave & Beatty Rd.
San Francisco, CA 94110
415-330-2960

BIENEFEZA, R.
Manager
Honda
1919 Torrance Blvd.
Torrance, CA 90501
310-783-3283

BETOURNE, CHRIS
Parts Sales Manager
Valley Detroit Diesel Allison
13644 Nelson Ave.
City of Industry, CA 91746
818-855-1386

BLACKBURN, BILL
Alternative Fuels Program
Calif. Energy Commission
1516 9th St., MS 41
Sacramento, CA 95814
916-654-4514

BLIGH, LARRY
Regional Mgr. Fleet Opr.
GTE California
112 Lakeview Canyon
Thousand Oaks, CA 91362
805-372-6997

BOLE, SPENCER
Deputy Dir., Dept. Gen. Svc.
County of Sacramento
3284 Ramos Circle
Sacramento, CA 95827
916-366-2111

BOW, TIMOTHY
Chief
Dept of General Services
802 Q St.
Sacramento, CA 95814
916-327-2007

BRANDT, CHRIS
Associate Editor
P&D Magazine
11344 Coloma Rd.
Gold River, CA 95670
916-852-5703

BROHAMER, JAMES
Fleet Manager
City of Redding
760 Parkview Ave.
Redding, CA 96001
916-225-4521

BRUNS, JUDY
Supervisor - M85
Chevron
2001 Diamond Blvd # 1276A
Concord, CA 94529
510-827-6328

BRUNSON, DON
Environmental Program Mgr.
Xerox Corp.
1851 East First St.
Santa Ana, CA 92705
714-565-1705

BURRITT-KELLY, CAROLYN
Coordinator Parking & Transp.
Alto Bates Medical Center
2850 Telegraph
Berkeley, CA 94705
510-204-1735

BRUCE, BUCKNER
Western Regional Sales Mgr.
Wilson Technologies Inc.
12118 S. Bloomfield Ave.
Santo Fe Springs, CA 90670
310-929-6789

CANNOBIO, VINCE
Sales Rep.
Olympian Oil
260 Michele Ct.
So. San Francisco, CA 94080
415-873-8200

CASTRO, ROSALINDA
Mgr, Aftermarket Parts
Air Resources Board
9528 Telstor Ave.
El Monte, CA 91731
818-575-6848

CERAGIOLI, JACKIE
Supv. - M85 Distribution
Chevron
2001 Diamond Blvd, 1276A
Concord, CA 94529
510-827-6328

CHIU, CARVER
Policy Planner
The Planning Center
1300 Dove St., Ste 100
Newport Beach, CA 92660
714-851-9444

CLEARY, MICHAEL
Sr. Special Investigator
CA. State Div of Meas. Std.
8500 Fruitridge Rd.
Sacramento, CA 95826
916-387-4819

COLE, RUSSELL
Operations Mgr.
Clean Air Fuels Corp.
1945 Las Plumas
San Jose, CA 95135
408-259-5910

COLON, AL
Dist. Div Chief Resource
Caltrans
P.O. Box 911, 703 "B" St.
Marysville, CA 95901
916-741-4244

COLLEDGE, RAYMOND
VP Market Development
American Methanol Institute
800 Conneticut Ave.
Washington, DC 20006
202-467-5050

CORBETT, MICHAEL
Editor
California Fleet News
1505 Warrington Rd.
Santa Rosa, CA 95404-9705
707-585-7995

COWLEY, DAVID
City Shops Gen. Supv.
City & County of S.F.
1800 Jerrold Ave.
San Francisco, CA 94124
415-550-4600

CRESENCIA, KIMBERLY
Environmental Analyst
San Diego Gas & Electric Co.
8306 Century Park Ct., 4200-C
San Diego, Ca 92123-1593
619-654-1107

CURTIS, CHRIS
Production Director
Video Svc. Assoc.
309 Wall St.
Chico, CA 95926
916-891-0315

DAHL, GREG
Office Administratar
Fleet Stor Inc.
1010 Hurley Way, Ste 300
Sacramenta, CA 95825
916-641-5999

DANIELSON, ROBERT
Mechanic
City of Santa Clarita
25663 Ave. Stanford
Santa Clarita, CA 91355
805-294-2536

DEAN, BOB
Sales
Drive Electric
1206 "C" St.
Sacramenta, Ca 95814
916-442-5110

DEE, STEVE
Environmental Specialist
SMUD
P.O. Box 15830
Sacramenta, Ca 95852
916-732-6143

DERBY, BRUCE
Fleet Manager
Toyota Motor Sales
19001 S. Western Ave.
Torrance, CA 90509-2991
310-618-5047

DEWITT, SUE
Electric Veh Prog. Mgr.
Calif. Energy Commission
1516 9th St., MS 41
Sacramenta, CA 95814
916-657-4245

DIAL, BILL
Maintenance Supv.
Mid-Placer Public Schools
P.O. Box 6857
Auburn, CA 95604
916-823-4820

DIXON, MARTHA
Director
S.F. Regional Support Ofc.
1301 Clay St, 1060N
Oakland, Ca 94612
510-637-1942

DONG, JAMES
Project Engineer
Raymundo Engr. Co. Inc.
P.O. Box 30425
Walnut Creek, CA 94598
510-988-0172

DRYER, TERRY
General Services Agency
800 So. Victoria Ave,
L #3120
Ventura, Ca 93009
(no phone given)

DUBOIS, DARA
Energy Analyst
Energy Commission
1516 9th St., MS 41
Sacramenta, CA 95814
916-654-4651

DUMANINI, PAT
CNG Station Marketing
Clean Air Transp. Products
123 Mission St. - H28C
San Francisco, CA 94177
415-973-2531

EGBERT, JILL
Clean Air Transp. Rep.
PG&E
5555 Florin Perkins Rd.
Sacramenta, CA 95831
916-386-5015

ELLIS, CHARLES
Dist. Mgr.
Suburban Propane
8724 So. 222 St.
Kent, WA 98031
206-872-6538

ELLISON, GED
Supv. Maint Opr & Transp.
Las Banos USD
1717 So. 11th St.
Los Banos, Ca 93635
209-826-3195

ELMENDORF, HANK
Marketing Consultant
Fleetstar Inc.
P.O. Box 16045
Fresno, CA 93755
800-765-6326

EMIG, DOUG
Mgr. Tech Eng. Support
Navistar Int'l Transp. Corp.
2694 Bishop Dr., Ste 100
San Ramon, Ca 94583
510-866-7233

ENGLISH, JOE
Sales Manager
PCI
2311 Magnolia St.
Oakland, Ca 94607
510-444-8081

ERICKSON, SPENCE
Clean Air Transp. Coord.
PG&E
356 E. Alisal St.
Salinas, CA 93901
408-755-3347

FAY, PATRICK
Forestry Equip. Mgr.
CA Dept of Foresty
Rte 1, Box 5950
Davis, CA 95616
916-322-5684

FELKINS, CATHY
Assoc. Trans. Planner
Caltrans
1304 "O" St.
Sacramenta, Ca 95831
916-323-5108

FERRARA, CHRIS
Account Rep.
PG&E
1030 Detroit Ave.
Concord, Ca 94518
510-674-6560

FERRANTE, VINCE
Moog Rep.
Moog
2001 Gateway Pl, Ste 740W
San Jose, CA 95110
408-441-9999

FIRENZE, RUSTY
Vice President Operations
Olympian Oil Co.
260 Michele Ct.
So. San Francisco, Ca 94080
415-873-8200

FLORES, ROMAN

GSA
2950 Kurt St. Ste B
San Diego, Ca 92108
619-557-5650

FORBES, LAURA
Transp. Consultant
Bevilacqua-Knight Inc.
501 14th St., Ste 200
Oakland, CA 94612
510-444-8707

FORNACIARI, ROBERT
Reporter
California Fleet News
1505 Warrington Rd.
Santa Rosa, Ca 95404-9705
707-585-7995

FRALEY, REBECCA
Auto Equip. Specialist
Lemoore Naval Air Station
Bldg 765
Lemoore, Ca 93246-5001
109-998-4184

FREEL, JOHN
Sr. Staff Scientist
Chevron Research & Tech. Co.
100 Chevron Way
Richmond, CA 94802
510-242-4080

FRIEDFEL, ARTHUR
Account Manager
U.S. Electricar
P.O. Box 6645
Santo Rosa, CA 95406
707-822-1215

FUNG, TOM
Auto Pool Manager
Dept. of General Services
1416 10th St.
Sacramento, CA 95814
916-327-2037

GAINEY, WILLIAM
Operations Manager
Clean Air Fuels Corp.
1945 Las Plumas
San Jose, CA 95133
408-259-5710

GARCIA, JOSEPH
Marketing
PG&E
123 Mission St., # 2537-H28C
San Francisco, Ca 94105
415-973-4162

GARCIA, ROGER
Director, Gen. Svc.
INS
P.O. Box 30080
Laguna Niguel, CA 92607
714-643-6042

GARZEE, BOB
VP Sales
U.S. Electricar
P.O. Box 6645
Santa Rosa, CA 95406
707-822-1215

GRAEBNER, MELISSA

Project California
100 Wilshire Blvd., Ste 1100
Santa Monica, CA 90401
310-260-4400

GREENE, BARBARA,
Asst Mgr. UCD Fleet Svc.
University of California
Fleet Services
Davis, CA 95616
916-752-9666

GREER, SHARON
Vehicle Maint. Prog. Ana.
U.S. Postal Service
475 L'Enfont Pl. SW
Washington, DC 20260
202-268-3576

GRUBB, TIM
Director of Transp.
Lemoore Union HSD
101 E. Bush St.
Lemoore, CA 93245
209-924-6640

GRUNDON, NORM
Mobile Equip. Opr.
State Dept. Water Resources
P.O. Box 942836, Rm 816
Sacramento, CA 94236
916-653-2950

GUTIERREZ JR., JAMES
Chief, Veh. Maint. Flight
722 Transp. Sqd/LGTM
5190 Air Guard Way
March AFB, CA 95818
909-655-7466

GUZMAN, WILLIAM
Heavy Mobile Equip. Supv.
Naval Air Weapons Station
P.W. Transportation
Point Mugu, CA 93042
805-989-7473

HAMILTON, BRODIE
Dir. Transp & Parking Svc.
University of California
Transportation & Parking Svc.
Davis, Ca 95616
916-752-3727

HAMMOND, CHUCK
Equip. Maint Supv.
City of Santa Rosa
55 Story Point Road
Santo Rosa, Ca 95403
707-543-3882

HANSEN, FREDERICK
Auto Emissions Instructor
City College of S.F.
1400 Evans Ave.
San Francisco, Ca 94124
415-550-4409

HANSEN, ROGER
Regional Fleet Sales Mgr.
Toyota Motor Dist. Inc.
2451 Bishop Dr.
San Ramon, Ca 94583
510-275-3320

HARGROVE, RICHARD
Sr. Insp. Auto Equip
Dept. of General Services
122 Sa. Hill
Los Angeles, CA
916-327-2037

HARRIS, JACK
Mgr. - UCD Fleet Services
University of California
Fleet Services
Davis, Ca 95616
916-752-7451

HASENJAGER, CINDY
Regulatory Affairs Coord.
CA Renewable Fuels Council
3304 Yorba Linda Bl., #249
Fullerton, CA 92341
714-990-3333

HATFIELD, GARY
SR. Engineer
PG&E
123 Mission St., Rm 2532
San Francisco, Ca 94177
415-973-2115

HAUGHT, MARK
NGV Specialist
Southwest Gas Corp.
P.O. Box 98510
Las Vegas, NV 89193
702-364-3255

HAYES, DAVID
VP Marketing & Admin.
MESA Environmental
3125 West Bolt St.
Ft. Worth, TX 76110
817-924-2353

HAYNES, FRED
Sr. Insp. Auto Equip.
Dept. of General Services
1421 Richards Blvd.
Sacramento, CA
916-327-2037

HEARD, ROBERT
FMC Fleet Manager
GSA
115 N. Rosemond Blvd.
Edwards AFB, CA 93523
805-258-7703

MARK, HILL
Technical Sales Rep.
Haskel Controls
100 East Graham Pl.
Burbank, Ca 91502
818-843-4000

HOBBS, ANDREW
Cummins Engine Co., Inc.
c/o Cummins West Inc.
1601 Aurora Dr.
San Leandro, Ca 94577
510-351-6101

HOFMAN, HAZEL
Air Quality Advisor
Cal State University
P.O. Box 3502
Seal Beach, CA 90740-7502
310-985-9658

HOLDER, OLIVER
Transp. Superintendent
Naval Air Weapons Station
P.W. Transportation
Point Mugu, CA 93042
805-989-8200

HOLLINGSHEAD, JIM
Consultant
Project California
100 Wilshire Blvd., Ste 1100
Santa Monica, CA 90401
310-260-4400

HOWELL, EARL
Assistant Chief
Dept. of General Services
802 Q St.
Sacramento, CA
916-327-2037

HOYLUND, HOMER
Port Equipment Supv.
Port of Oakland
530 Water St.
Oakland, Ca 94607
510-577-4045

HUNT, JERRY
Alternative Fuel Manager
Detroit Diesel Corp.
2808 San Ardo
Belmont, CA 94002
415-593-6263

HUNSBERGER, Mark
—
MVP Inc.
3808 Rosecrans, Suite 48
San Diego, CA 92110
(no phone given)

HURD, LONNIE
APMI
Metropolitan State Hospital
11400 Norwalk Blvd.
Norwalk, CA 90650
310-863-7011

IUDICE, KEITH
Head Mechanic
Los Banos Unified School Dist.
1717 S. 11th St.
Los Banos, Ca 93635
209-826-3195

JACKSON, ROBERT
Transportation Planner
Caltrans
P.O. Box 942874
Sacramento, CA 94274-0001
916-654-8631

JEWEL, PAUL
Associate Planner
Nelson\Nygaard
833 Market St. #900
San Francisco, Ca 94103
415-284-1544

JOHNSON, DAN
Maint Shop Foreman
Lemoor Naval Air Station
Bldg 765
Lemoore, CA 93246-5001
209-998-4189

JOHNSON, MAGGIE
Envir. Compliance Mgr.
Norcal Waste Systems
5 Thomas Mellon Circle
San Francisco, Ca 94134
415-330-1187

KAMDAR, PEARL
Market Dev. Mgr.
IMPCO Technologies, Inc.
16804 Gridley Pl.
Cerritos, Ca 90703
310-860-6666

KEEBLER, KELLY
Tranp. Sq. Env.
30 Trans/LGTM
1221 California Blvd.
Vandenberg AF8, CA 93437
805-734-8232

KING, ORVILLE
Sheriff
Orange County
550 N. Flower
Santa Ana, Ca 92701
714-647-4133

KERR, DAVE

So. CA Econ. Partnership
505 King Ave.
Columbus, OH 43201
614-424-5596

KOHATSU, Y.
Assoc. Env. Mgmt. Analyst
Port of San Diego
P.O. Box 488
San Diego, CA 92112
619-686-6254

KOYAMA, KENNETH
Pgm. Mgr. Alternative Fuels
Calif. Energy Commission
1516 9th St., MS 41
Sacramenta, CA 95814
916-654-4641

KUMPULAINIEN, JOHN
Sr. Inspectar Auta Equip.
Dept. of General Services
802 Q St.
Sacramenta, Ca 95814
916-327-2037

KUNKLE, JOHN
Fleet Services Supv.
City of Long Beach
2801 E. Willow St.
Long Beach, Ca 90806
310-570-5406

LACAMERA, JOHN
Fleet Purchasing
Caltrans
34th & Stockton
Sacramenta, CA 95816
916-227-9732

LANGLEY, DAVE
Marketing Rep.
Westinghouse Electric Corp.
3550 Watt Ave., Ste 140
Sacramento, CA 95825
916-979-7002

LASIC, DAVID
Mgr., Vehicle Maintenance
U.S. Postal Service
3775 Industrial Blvd.
W Sacramento, CA 95799
916-373-8206

LEDBETTER, GEORGE
VP Marketing
Hurricane Compressor
2442 NW Market #421
Seattle, WA 98107
206-781-9627

LEIB, DUANE
General Services Director
County San Luis Obispo
Co. Gov Center
SL Obispo, CA 93408
805-781-5200

LESSUISE, GARY
Ford Motar Company
Fairlane Business Part III
1555 Fairlane Dr., Rm 243J
Allen Park, MI 48101
313-845-3367

LOTT, MARK
General Facilities Supv.
Alameda Co. Water Dist.
43885 S. Grimmer Blvd.
Fremont, CA 94537
510-659-1970

LOVELACE, WILLIAM
Mgr, Regulatary Section
Air Resources Board
2020 L St.
Sacramento, CA 95814
916-327-7214

LUCERO, TOM
Auta Tech. Supv.
UC Davis Medical Center
2800 49th St.
Sacramenta, CA 95817
916-734-2498

MCCANN, CRAIG
—
Pro Electric Vehicles
11852 Eddy Ranch Road
Penn Valley, CA 95946
916-432-5244

MCCANN, DAN
Chief, Auto Div.
County of Sacramenta
725 7th St.
Sacramenta, CA 95814
916-440-6462

MCELHANEY, MICHAEL
Western Sales Manager
CP Industries
1369 S. Columbine St.
Denver, CO 80210
303-871-9380

MCGARVEY, EILEEN
Inspector Auto Equip.
Dept. of General Services
802 Q St.
Sacramento, CA 95814
916-327-2037

MADRIGAL, ROBERTO
Supv. Auto. Transp. Spec.
U.S. Navy Public Works Center
2730 McKean St., Ste 1
San Diego, Ca 91911
619-556-7601

MALONEY, FRED
Mgr. Alt. Fuel Vehicle Prog.
Chrysler Corp.
800 Chrysler Dr. E CIMS 483-03-10
Auburn Hills, MI 48236-2757
810-576-5472

MARELLI, MIKE
—
Sa. Cal Gas
555 W. 5th St., ML 2500
Los Angeles, CA 90013
213-244-3531

MARTIN, CECILE
Deputy Director
CA Electric Transp. Coalition
925 L St., Ste 1490
Sacramenta, CA 95814
916-552-7077

MEANS, LINDA
Manager, Market Development
Aerojet
P.O. Box 13222
Rancho Cordova, CA 95670
916-355-2711

MEDINA, ERNIE
Equipment Svc. Manager
City of Woodland
300 First St.
Woodland, CA 95695
916-661-5956

MESSER, COLIN
Director, Energy Tech Trng.
College of the Desert
43-500 Monterey Ave.
Palm Desert, CA 92260
619-773-2596

MIDDLETON, MIKE
Lead Auta Mechanic
Camarillo State Hospital
1878 Sa. Lewis Rd.
Camarillo, CA 93010-602
805-389-2854

MILLER, STEVE
Fleet Manager
City of Concord
1950 Parkside Dr. MS 31
Concord, CA 94519
510-671-3068

MAUS, DEBORAH
Marketing Manager
SMAQMD
B475 Jackson Rd #215
Sacramento, CA 95826
916-386-6685

MILAM, CHUCK
Project Manager Alt. Fuel
Valley Detroit Diesel Allison
13644 E. Nelson Ave.
City of Industry, CA 91746
818-855-1435

MILES, MIKE
District Div. Chief
CALTRANS
247 W. Third St.
San Bernardino, CA 92402
909-383-6484

MOORE, JOHN
Alternative Fuels Program
Calif. Energy Commission
1516 9th St., MS 41
Sacramento, CA 95814
916-656-3950

MOORE, R.E. "GENE"
Fleet & Facility Manager
City of Sacramento
5730 24th St., Bldg 1
Sacramento, CA 95822
916-433-6230

MORALES, ERNIE
Program Manager
Southern California Edison
P.O. Box 800
Rosemead, CA 91770
818-302-4363

MORI, DAVID
Associate I
Jakes Assoc., Inc.
San Jose Office Plaza
1735 N. 1st St., Ste 302-A
408-453-7201

MOYER, CARL
Chief, Specialist
Acurex Environmental Corp.
P.O. Box 7044
Mauntoin View, CA 94039
415-254-2415

MUNDY, GENE
Project Manager
Glendale Com. College PDC
2340 Honalulu Ave.
Montrose, CA 91020
818-957-0024

MURPHY, MICHAEL
Supv. Envir. Planner
Bay Area AQMD
939 Ellis St.
San Francisco, CA 94109
415-749-4644

MYERS, BOB
Executive Director
Western Propane Gas Assn.
2102 Business Ctr. Dr.
Irvine, CA 92715
714-253-5757

MUSLUSKY, DAN
Vehicle Maint. Supv.
Oceanside USD
2111 Missian Ave.
Oceanside, CA 92054
619-433-0040

NEVIN, DAN
General Mgr. Auto Bus.
Cummins West, Inc.
1601 Aurora Dr.
San Leandro, CA 94577
510-351-6101

NUNEZ, JOE
Auto Pool Manager
Dept. of General Services
1025 P. St.
Sacramento, CA 95814
916-327-2037

NUPUR, MEENA
Contract Envir. Consultant
U.S. Postal Service
3775 Industrial Blvd.
W Sacramento, CA 95799
916-373-8710

NANTZ, ANDREW
Director, Clean Fuels Prog.
Yala-Solano AQMD
1947 Galileo Ct., Ste 103
Davis, CA 95616
916-757-3650

NERLAND, KENNETH
Fleet Manager
City of Fresno
2101 "G" St., Bldg F
Fresna, CA 93706
209-498-1397

O'CONNELL, LARRY
Manager Technical Support
EPRI
501 Fourteenth St., Ste 200
Oakland, CA 94612
510-444-8707

OHST, DAVID

Westinghause Electric Carp.
401 East Hendy Ave.
Sunnyvale, CA 9408B
408-735-3511

PATTERSON, SANDY
—
City Pasadena
912 Balboa
Arcadia, CA 91007
81B-446-1986

PATTERSON, SUSAN
Light-Duty Veh. Program
Calif. Energy Commission
1516 9th St, MS 41
Sacramento, CA 95814
916-654-4992

PAGEULATOS, SOPHIA
Administrative Analyst
City of Davis
23 Russell Blvd.
Davis, CA 95616
916-757-5626

PAUL, ALAN
Associate V.P.
PMR Group Inc.
11906 Wilshire Blvd., Ste 24
Los Angeles, CA 90025
310-473-8168

PEARSON, BARRY
President
Pacific Electric Vehicles
8500 Weyand Ave.
Sacramento, CA 95828
916-381-3509

PEDERSEN, CHRISTOPHER
President
Pedersen Consulting Group
701 Brazos, Ste 500
Austin, TX 7B701
512-320-9131

PENNINO, PHILLIP
Clean Air Transp. Coord.
PG&E
4040 West Lane
Stockton, CA 95204
209-942-1730

PEPPER, BRIAN
Natural Gas Vehicles
PG&E
123 Missian St. H28C
San Francisca, CA 94177
415-973-2471

PERASSO, GREG
Sale & Tech. Rep.
American Gas Equipment
P.O. Box 907
Dixan, CA 95620
916-678-1878

PEREZ, PAT
Supervisor II
Calif. Energy Commission
1516 9th St., MS 45
Sacramento, CA 95B14
916-654-4527

PHILLIPS, DALE
Supv. Hwy Equip
Caltrans Equip. Svc. Ctr.
34th & Stockton
Sacramento, CA 95816
916-227-9705

POPE, GARY
National Sales Manager
Liquid Carbonic - CNG Div.
P.O. Box 57
Huntington Bch, CA 92648
714-536-4900

POSTUMA, DAVE
Western Regian Manager
IMW Atlas
23411 Summerfield #35-G
Aliso Viejo, Ca 92656
714-448-9249

PREISSLER, PETER
—
Sulber Technology Corp.
1255 Post. St.
San Francisco, CA 94109
415-441-7230

PRICE, RICK
Account Executive
Sa. Cal Gas Company
555 W 5th St.
Los Angeles, CA 90013
213-244-3679

PRITCHARD, DEBRA
Transportation Planner
Dept. of Transportation
1227 "O" St.
Sacramento, CA 942874
916-654-9396

RAYMUNDO, WILLIAM
President
Raymundo Engineering Co.
P.O. Box 30425
Walnut Creek, CA 94598
510-988-0172

REED, NATHANIEL
Chief, Operations
Fleet Management Branch
525 Market St. 9F8F
San Francisco, CA 94105
415-744-6077

REEDER, RUSSELL
General Manager
Cardinal Auto Inc.
2424 E. Olympic Blvd., Bldg 3
Los Angeles, CA 90021
213-689-1973

REDICK, CHUCK
Account Manager
The Bus Stop Inc.
2100 L. St.
Newman, CA 95360
209-862-4100

RICHARD, HOWARD
—
General Services Agency
800 Sa. Victoria Ave. L-3120
Ventura, CA 93009
805-654-3750

RICKETT, JERRY
Airport Equip. Maint. Supv.
County of Sacramento
7207 Earhart Dr.
Sacramento, Ca 95837
916-648-0745

RIBNICK, JERRY
—
Coas Inc.
4000 Olson Memorial Hwy #502
Minneapolis, MN 55422
612-521-1515

RICHARDS, ELIZABETH
Program Manager
Solano Commuter Info.
333 Sunset Ave., Ste 230
Suisun City, CA 94585
707-421-7979

RIDING, BOB
Clean Air Transp. Coordinator
PG&E
705 P St., 3rd Fl.
Fresno, CA 93760-0001
209-263-5530

RODES, DON
—
Pra Electric Vehicles
11852 Eddy Ranch Rd.
Penn Valley, Ca 95946
916-432-5244

RODRIGUEZ, SAUL
Assistant Chief
Dept. of General Services
802 Q St.
Sacramento, CA 95814
916-327-1884

ROSEBROOK, DEAN
Regional Fleet Manager
Airborne Express
605 Laurelwood Rd.
Santa Clara, CA 95054
408-880-8795

ROSER, RANSON
Engineer
Env. Mgmt. Dept. Clean Fuels
8475 Jackson Rd #200
Sacramento, CA 95826
916-386-6640

ROUSE, PAUL
Equipment Maint. Supv.
City of Modesto
621 11th St.
Modesto, CA 95354
209-577-5309

RUSH, BRYON
Mobile Equip. Opr.
State of California
P.O. Box 942836, Rm 816
Sacramento, CA 94236
916-653-2950

SAGE, BRUCE
—
City of Concord
1950 Parkside Dr.
Concord, CA 94519
510-671-3068

SANCHEZ-ADAMS, RUSSEL
Sant Engr.
Sanchez Adams Consult.
1296 E. Gibson Rd., Ste 259
Woodland, Ca 95776
916-662-5399

SCARBROUGH, KEN
Administrator Fleet Oper.
GTE California
112 Lakeview Canyo,
Thousand Oaks, Ca 91362
805-372-7889

SCHROEDER, SHAUNA
Marketing & Public Relations
Speciality Veh. Mfg. Corp.
9250 Washburn Rd.
Downey, CA 90242
310-904-3434

SELLERS, MICHAEL
Police Lt.
City of LaPalma
7792 Walker St.
La Palma, CA 90623
714-523-4552

SALAZAR, IRENE
Alternative Fuels Program
Calif. Energy Commission
1516 9th St., MS 41
Sacramento, Ca 95814
916-657-4046

SHANAHAN, KEVIN
President
Cummins West, Inc.
1601 Aurora Drive
San Leandra, Ca 94577
510-351-6101

SHEPARD, PAUL
Fleet Manager
City of Visalia
336 N. Ben Maddox
Visalia, CA 93292
209-738-3209

SEYMOUR, GAIL
Alternative Fuels Program
Calif. Energy Commission
1516 9th St., MS 41
Sacramento, CA 95814
916-654-4683

SHOWERS, HERMAN
Auto Pool Manager
Dept. of General Services
122 Sa. Hill St.
Los Angeles, CA 90012
213-327-2037

SIMON, RICHARD
Fleet Manager
County of Santa Clara
95 West Younger St.
San Jose, CA 95110
408-299-2357

SLAMA, RICK
Alt. Fuel Veh. Coordinator
Dept. of General Services
802 Q St.
Sacramento, CA 95814
916-327-2567

SKRIPKA, FRED
Fleet Manager
Monterey County Fleet Mgmt.
855 E. Laurel Dr. Bldg A
Salinas, CA 93905
408-755-4984

SMITH, ROSALIND
Asst. Air Resources Spec.
San Diego Cauty Air Pol Cont.
9150 Chesapeake Dr.
San Diego, CA 92123
619-694-3570

SMOCK, PAUL
CNG Coordinator
City of Long Beach
2400 E. Spring St.
Long Beach, Ca 90806
310-570-2052

SMOKOSKA, KENNETH
Commercial Sales Manager
Today Motor Co.
1345 N. Oxnard Blvd.
Oxnard, Ca 93030
805-983-6800

SNEE, GREG
—
UC San Diego
9500 Gilman Dr.
La Jolla, Ca 92093
619-534-7437

SORIANO, STEVE
Lead Mechanic
City of Sunnyvale
P.O. Box 3707
Sunnyvale, Ca 94088-3707
408-730-7569

SPAK, DANIEL
Business Development
Westinghouse Electric Corp.
18901 Euclid Ave.
Cleveland, OH 44117
408-736-1611

STEDMAN, K.
Fleet Manager
Adahr Farms Dairy Inc.
4002 W. Westminster Ave.
Santa Ana, CA 92703
714-775-5076

STOCKWELL, HARRY
Instructor
El Comino Community College
16007 Crenshaw Blvd.
Tarrance, CA 90506
310-660-3600

SULLIVAN, CINDY
Program Supervisor
Sa. Coast AQMD
21865 E. copley
Diamond Bar, CA 92704
909-396-3249

SUMMERSETT, ROBERT
Assistant Fleet Manager
City of Sacramenta
5730 24th St., Bldg 5
Sacramento, Ca 95822
916-433-6230

SWENSON, TOM
Assoc. Engr.
Sacramento Metro AQMD
8475 Jackson Rd. Ste 215
Sacramenta, CA 95758
916-386-7001

SYBERT, NEIL
Sr. Program Planner
San Diego Gas & Electric
8306 Century Park Ct.
San Diego, CA 92123
619-654-1109

TAFOYA, ELIZABETH
AGPA
DMV
2120 Broadway
Sacramenta, CA 95818
916-657-8824

TAKAHASHI, CHARLENE
Business Service Officer
DMV
2415 1st Ave., MS A195
Sacramenta, CA 95818
916-656-7571

TAYLOR, TIMOTHY
Director
Env. Mgmt. Dev.
8475 Jackson Rd. #200
Sacramenta, CA 95826
916-386-6640

TEAGUE, JONATHAN
Assoc. Energy Spec.
Calif. Energy Commission
1516 9th St., MS 41
Sacramento, Ca 95814
916-657-4774

THOMAS, WILLIAM
Supv. Medium Truck Prod.
Freightliner Corp.
4747 N. Channel Ave.
Portland, OR 97217
503-735-8896

THORESEN, MICHAEL
VP Account Supervisor
J. Walter Thompson
500 Woodward Ave.
Detroit, MI 48226
313-964-2887

TILLERY, GEORGE
President
A-Z Bus Sales, Inc.
P.O. Box 700
Colton, Ca 92324
909-781-7188

TOM, GWOON
Segment Bus. Policy Mgr.
Southern Calif. Gas Co.
P.O. Box 3249, ML 25D0
Los Angeles, CA 90051
213-244-3692

TRUE, RAMON
Clean Air Transp. Coord.
PG&E
1970 Industrial Way
Belmont, Ca 94002
415-598-7476

TRUJILLO, MICHAEL
Automotive Engineer
Calif. Energy Commission
1516 9th St.
Sacramenta, CA 95814
916-654-4566

TURNER, DENNIS
Equipment Maint. Supv.
City of Modesta
621 11th St.
Modesto, CA 95354
209-5775309

UPDEGROVE, AL
Ford Motor Company
Fairlane Business Park III
1555 Fairlane Dr., Rm 243J
Allen Park, MI 48101
313-845-3367

VANDEMARK, STEVE
Western Area Sales Mgr.
Trillium USA
19 Osoberry St.
Rancho Santa Margarita, CA 92688
714-439-0047

VANVLEET, MARISA
Environmental Assistant
Sea World of CA
1727 South Shores Rd.
San Diego, CA 92109
619-226-3901

VARGAS, MARIANO
Fleet Services Rep.
SCAQMD
21865 Copley Dr.
Diamond Bar, CA 91725
909-396-2045

VERA, LIONEL
Technology Marketing Spec.
U.S. Dept of Energy
1301 Clay St., 1060 North
Oakland, Ca 94612
510-637-1945

VILLENEUVE, JOHN
San Joaquin Valley
Unified Air Pol Control Dist.
1999 Tuolumne St. #200
Fresno, CA 93721
209-497-1075

WAKE, BILL
—
Federal Express
8950 Cal Center Dr.
Sacramenta, CA 95826
916-361-5885

WARD, PETER
Fuel Dist. Program Mgr.
Calif. Energy Commission
1516 9th St., MS 41
Sacramenta, CA 95814
916-654-4639

WARDEN, ROBERT
Principal Planning Consult.
Chevron USA
575 Market St.
San Francisco, CA 94707
415-894-3440

WASHINGTON, VALERIE
Manager, Vanpool Services
Rides for Bay Area Commuters
60 Spears St., Ste 650
San Francisco, CA 94105
415-861-7665

WATSON, DENNIS
Equipment Fleet Supv.
City of Ontario
1425 S. Bon View Ave.
Ontario, CA 91761
909-391-2507

WEAVER, ROGER
Director, Fleet Opr.
McKesson Water Products Co.
3280 East Foothill Bl., Ste 400
Pasadena, CA 91107
818-585-1041

WEBSTER, EDWARD
Administrative Assistant
County of Ventura
800 S. Victoria Ave.
Ventura, CA 93023
805-654-2703

WEDDLE, KEVIN
President
Golden State Natural Gas Sys.
1747 Live Oak Blvd Ste J
Yuba City, CA 95991
916-696-2234

YEHLE, RICHARD
Environmental Coordinator
U.S. Postal Service
3775 Industrial Blvd.
West Sacramenta, CA 95799
916-373-8702

WEIR, THOMAS
Maint. Mech. Facility Svc.
Fleet Maintenance
California State University
San Marcos, Ca 92096
619-750-4000

WELLS, RICK
—
M&M Electric
1600 Auburn Blvd.
Sacramento, CA 95815
916-929-0150

WIENS, JERRY
Heavy Duty Truck Proj. Mgr.
Calif. Energy Commission
1516 9th St., MS 41
Sacramento, CA 95814
916-654-4649

WING, BRIAN
Marketing Engineer
PG&E
24300 Clawiter Rd.
Hayward, CA 94545
510-784-2109

WONG, JANE
Staff Services Analyst
DMV
2415 1st Ave. MS E251
Sacramenta, Ca 95818
916-657-5763

WRIGHT, LOIS
Govt. Affair Rep.
Sac Municipal Util Dist
P.O. Box 15830 - MS30A
Sacramento, CA 95852
916-732-6143

WUEBBEN, PAUL
Clean Fuels Officer
South Coast Air Quality
21865 E. Copley Dr.
Diamond Bar, Ca 91765
310-863-7011

YOUNG, CLAUDE ALLEN
Chief, Plant Operations
Metropolitan State Hospital
11400 Norwalk Blvd.
Norwalk, CA 90650
310-929-1054

ZANKICK, MARTY
Lead Mechanic
City of Sunnyvale
P.O. Boc 3707
Sunnyvale, Ca 94088-3707
408-730-7569

Notes